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Test report

318432TRFWL

Date of issue: July 3, 2017

Applicant:
SECO srl
Via Calamandrei, 91 – 52100 Arezzo – Italy

Product:
Mini PC

Model:
UDOO X86 Advanced Plus

FCC ID: 2ALZB-SECOFCC1

IC Registration number: 22688-SECOIC1

Specifications:

- FCC 47 CFR Part 15 Subpart C, §15.247
  Operation in the 902–928 MHz, 2400–2483.5 MHz, and 5725–5850 MHz
- RSS-247, Issue 2, February 2017, Section 5
  Digital Transmission Systems (DTSs), Frequency Hopping Systems (FHSs) and Licence-Exempt Local Area Network (LE-LAN) Devices

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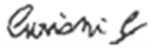
Reviewed by (name, function and signature)	Gabriele Curioni	(verifier)	
Review date	July,03 2017		

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Section 1. Report summary

1.1 Applicant and manufacturer

Company name	SECO srl
Address	Via Calamandrei, 91
City	Arezzo
Province/State	AR
Postal/Zip code	52100
Country	Italy

1.2 Test specifications

FCC 47 CFR Part 15, Subpart C, Clause 15.247	Operation in the 902–928 MHz, 2400–2483.5 MHz, and 5725–585 MHz
RSS-247, Issue 2, February 2017, Section 5	Digital Transmission Systems (DTSs), Frequency Hopping Systems (FHSs) and Licence-Exempt Local Area Network (LE-LAN) Devices

1.3 Test methods

558074 D01 DTS Meas Guidance v03r05 (April 8, 2016)	Guidance for Performing Compliance Measurements on Digital Transmission Systems (DTS) Operating Under §15.247
ANSI C63.10 v2013	American National Standard of Procedures for Compliance Testing of Unlicensed Wireless Devices

1.4 Statement of compliance

In the configuration tested, the EUT was found compliant.

Testing was completed against all relevant requirements of the test standard. Results obtained indicate that the product under test complies in full with the requirements tested. The test results relate only to the items tested.

See “Summary of test results” for full details.

1.5 Exclusions

None

1.6 Test report revision history

Revision #	Details of changes made to test report
318432TRFWL	Original report issued

Section 2. Summary of test results

2.1 FCC Part 15 Subpart C, general requirements test results

Part	Test description	Verdict
§15.207(a)	Conducted limits	Pass
§15.31(e)	Variation of power source	Pass[1]
§15.203	Antenna requirement	Pass[2]

Notes: [1] Measurements of the variation of the input power or the radiated signal level of the fundamental frequency component of the emission, as appropriate, was performed with the supply voltage varied between 85 % and 115 % of the nominal rated supply voltage. No noticeable output power variation was observed

[2] The Antenna is located within the enclosure of EUT and not user accessible.

2.2 FCC Part 15 Subpart C, intentional radiators test results

Part	Test description	Verdict
§15.247(a)(1)(i)	Frequency hopping systems operating in the 902–928 MHz band	Not applicable
§15.247(a)(1)(ii)	Frequency hopping systems operating in the 5725–5850 MHz band	Not applicable
§15.247(a)(1)(iii)	Frequency hopping systems operating in the 2400–2483.5 MHz band	Not applicable
§15.247(a)(2)	Minimum 6 dB bandwidth for systems using digital modulation techniques	Pass
§15.247(b)(1)	Maximum peak output power of frequency hopping systems operating in the 2400–2483.5 MHz band and 5725–5850 MHz band	Not applicable
§15.247(b)(2)	Maximum peak output power of Frequency hopping systems operating in the 902–928 MHz band	Not applicable
§15.247(b)(3)	Maximum peak output power of systems using digital modulation in the 902–928 MHz, 2400–2483.5 MHz, and 5725–5850 MHz bands	Pass
§15.247(c)(1)	Fixed point-to-point operation with directional antenna gains greater than 6 dBi	Not applicable
§15.247(c)(2)	Transmitters operating in the 2400–2483.5 MHz band that emit multiple directional beams	Not applicable
§15.247(d)	Spurious emissions	Pass
§15.247(e)	Power spectral density for digitally modulated devices	Pass
§15.247(f)	Time of occupancy for hybrid systems	Not applicable

2.3 IC RSS-GEN, Issue 4, test results

Part	Test description	Verdict
7.1.2	Receiver radiated emission limits	Not applicable
7.1.3	Receiver conducted emission limits	Not applicable
8.8	Power Line Conducted Emissions Limits for Licence-Exempt Radio Apparatus	Pass

Notes: [1] According to sections 5.2 and 5.3 of RSS-Gen, Issue 4 the EUT does not have a stand-alone receiver neither scanner receiver, therefore exempt from receiver requirements.

2.4 IC RSS-247, Issue 2, test results

Part	Test description	Verdict
5.1	Frequency Hopping Systems (FHSs)	
5.1 (a)	Bandwidth of a frequency hopping channel	Not applicable
5.1 (b)	Minimum channel spacing for frequency hopping systems	Not applicable
5.1 (c)	Frequency hopping systems operating in the 902–928 MHz band	Not applicable
5.1 (d)	Frequency hopping systems operating in the 2400–2483.5 MHz band	Not applicable
5.1 (e)	Frequency hopping systems operating in the 5725–5850 MHz band	Not applicable
5.2	Digital Transmission Systems (DTSs)	
5.2 (a)	Minimum 6 dB bandwidth	Pass
5.2 (b)	Maximum power spectral density	Pass
5.3	Hybrid Systems	
5.3 (1)	Digital modulation turned off	Not applicable
5.3 (2)	Frequency hopping turned off	Not applicable
5.4	Transmitter output power and e.i.r.p. requirements	
5.4 (a)	Frequency hopping systems operating in the 902–928 MHz band	Not applicable
5.4 (b)	Frequency hopping systems operating in the 2400–2483.5 MHz band	Not applicable
5.4 (c)	Frequency hopping systems operating in the 5725–5850 MHz	Not applicable
5.4 (d)	Systems employing digital modulation techniques	Pass
5.4 (e)	Point-to-point systems in 2400–2483.5 MHz and 5725–5850 MHz band	Not applicable
5.4 (f)	Transmitters which operate in the 2400–2483.5 MHz band with multiple directional beams	Not applicable
5.5	Out-of-band emissions	Pass

Notes: None

Section 3. Equipment under test (EUT) details

3.1 Sample information

Receipt date	July 3, 2017
Nemko sample ID number	318432

3.2 EUT information

Product name	Mini PC
Model	UDOO X86 Advanced Plus
Model variant	-
Serial number	1/1 (Number assigne by Nemko Spa)

3.3 Technical information

Applicant IC company number	22688
IC UPN number	SECOIC1
All used IC test site(s) Reg. number	9109A
RSS number and Issue number	RSS-247 Issue 2, February 2017
Frequency band	2400–2483.5 MHz
Frequency Min (MHz)	2402 MHz
Frequency Max (MHz)	2480 MHz
RF power Min (W), Conducted	1.8 mW (2.6 dBm)
RF power Max (W), Conducted	2.0 mW (3.0 dBm)
Field strength, Units @ distance	N/A
Measured BW (kHz) (99%)	1.05 MHz
Calculated BW (kHz), as per TRC-43	N/A
Type of modulation	BLE
Emission designator	1M05F7D
Transmitter spurious, Units @ distance	50.0 dBµV/m @ 3 m
Power requirements	100-240V-50/60Hz
Antenna information	Model ANT016008LCD2442MA1 (TDK) with max gain of 2.3 dBi on the EUT PCB The EUT uses a unique antenna coupling/ non-detachable antenna to the intentional radiator.

3.4 Product description and theory of operation

The EUT is a mini PC provided with a Bluetooth Low Energy radio module

3.5 EUT exercise details

A CuteCom software has been used to put the EUT in continuous transmission mode as following:

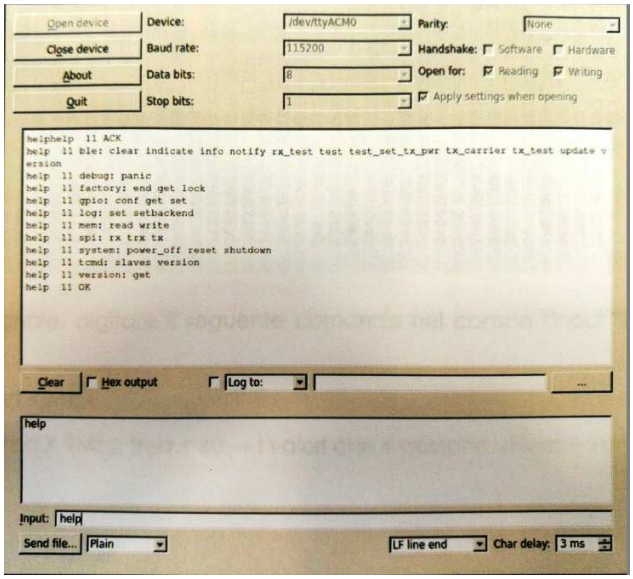


Figure 3.5-1: *CuteCom software*

Figure 3.5-2: *EUT modification to use the soktware*

3.6 Antenna requirement

Figure 3.6-1: *The Antenna is located on the PCB of EUT and not user accessible.*

3.7 EUT setup diagram

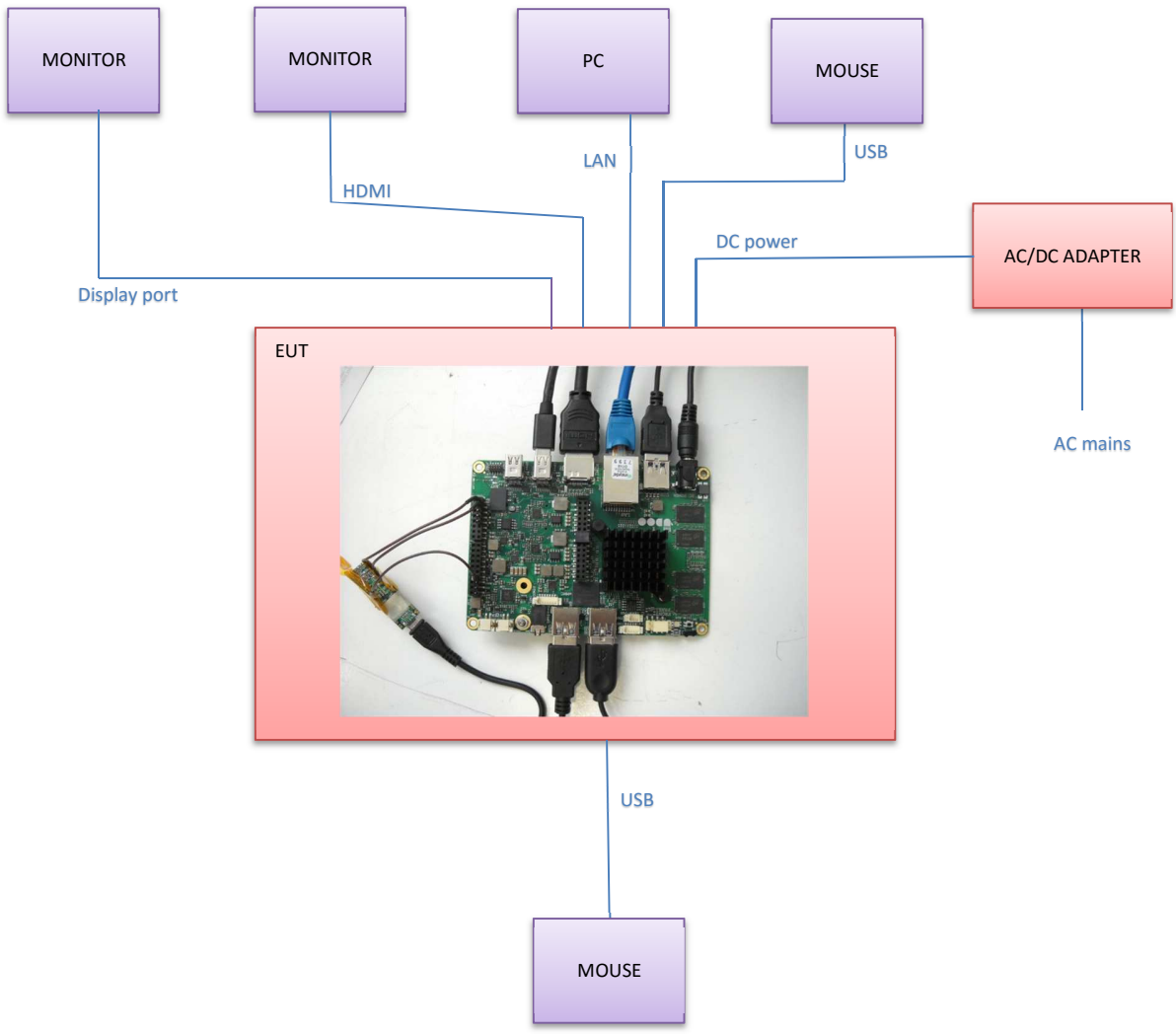


Figure 3.7-1: *Setup diagram*

Section 4. Engineering considerations

4.1 Modifications incorporated in the EUT

There were no modifications performed to the EUT during this assessment.

4.2 Technical judgment

None

4.3 Deviations from laboratory tests procedures

No deviations were made from laboratory procedures.

Section 5. Test conditions

5.1 Atmospheric conditions

Temperature	15–30 °C
Relative humidity	20–75 %
Air pressure	860–1060 mbar

When it is impracticable to carry out tests under these conditions, a note to this effect stating the ambient temperature and relative humidity during the tests shall be recorded and stated.

5.2 Power supply range

The normal test voltage for equipment to be connected to the mains shall be the nominal mains voltage. For the purpose of the present document, the nominal voltage shall be the declared voltage, or any of the declared voltages ±5 %, for which the equipment was designed.

Section 6. Measurement uncertainty

6.1 Uncertainty of measurement

The reported expanded uncertainty of measurement is stated as the standard uncertainty of measurement multiplied by the coverage factor k = 2 which has been derived from the assumed normal probability distribution with infinite degrees of freedom and for a coverage probability of 95 %.

EUT	Type	Test	Range and Setup features	Measurement Uncertainty	Notes
Transmitter	Conducted	Frequency error	0.001MHz ÷ 18 GHz	0.08 ppm	(1)
		Carrier power RF Output Power	1MHz ÷ 18 GHz With power meter	1.6 dB	(1)
			1MHz ÷ 18 GHz With spectrum/receiver	3.0 dB	(1)
		Adjacent channel power	1MHz ÷ 18 GHz	1.6 dB	(1)
		Conducted spurious emissions	1MHz ÷ 18 GHz	4.2 dB	(1)
		Intermodulation attenuation	1MHz ÷ 18 GHz	2.2 dB	(1)
		Attack time – frequency behaviour	1MHz ÷ 18 GHz	2.0 ms	(1)
		Attack time – power behaviour	1MHz ÷ 18 GHz	2.5 ms	(1)
		Release time – frequency behaviour	1MHz ÷ 18 GHz	2.0 ms	(1)
		Release time – power behaviour	1MHz ÷ 18 GHz	2.5 ms	(1)
		Transient behaviour of the transmitter– Transient frequency behaviour	1MHz ÷ 18 GHz	0.2 kHz	(1)
		Transient behaviour of the transmitter – Power level slope	1MHz ÷ 18 GHz	9%	(1)
		Frequency deviation - Maximum permissible frequency deviation	0.001MHz ÷ 18 GHz	1.3%	(1)
		Frequency deviation - Response of the transmitter to modulation frequencies above 3 kHz	0.001MHz ÷ 18 GHz	0.5 dB	(1)
		Dwell time	-	3%	(1)
		Hopping Frequency Separation	0.01MHz ÷ 18 GHz	1%	(1)
		Occupied Channel Bandwidth	0.01MHz ÷ 18 GHz	2%	(1)
		Modulation Bandwidth	0.01MHz ÷ 18 GHz	2%	(1)
	Radiated	Radiated spurious emissions	30MHz ÷ 18 GHz	6.0 dB	(1)
		Effective radiated power transmitter	30MHz ÷ 18 GHz	6.0 dB	(1)
Receiver	Radiated	Radiated spurious emissions	30MHz ÷ 18 GHz	6.0 dB	(1)
		Sensitivity measurement	1MHz ÷ 18 GHz	6.0 dB	(1)
	Conducted	Conducted spurious emissions	1MHz ÷ 18 GHz	4.2 dB	(1)

Section 7. Test equipment

7.1 Test equipment list

Table 7.1-1: *Equipment list*

Equipment	Manufacturer	Model no.	Serial no.	Next cal.
Spectrum Analizer (9 KHz ÷ 40 GHz)	R&S	FSEK	848255/005	2018/01
EMI receiver (20 Hz ÷ 8 GHz)	R&S	ESU8	100202	2017/09
Broadband preamplifier (1 GHz ÷ 18 GHz)	Schwarzbeck	BBV 9718	9718-137	2017/12
Bilog antenna (1 GHz ÷18 GHz)	Schwarzbeck	STLP 9148	9148-123	2018/06
Trilog Broadband Antenna	Schwarzbeck	VULB 9162	9162-025	2018/07
Double Ridged Horn (4 GHz ÷ 40 GHz)	RF SPIN	DRH40	061106A40	2017/08
Wide band Amplifier (18 GHz ÷ 40 GHz)	MITEQ	JS44-18004000-35-8P-R	1.627	2017/12
Semi-anechoic chamber	Nemko	10m semi-anechoic chamber	530	2018/10
Antenna mast	R&S	HCM	836 529/05	NCR
Controller	R&S	HCC	836 620/7	NCR
Turning-table	R&S	HCT	835 803/03	NCR

Note: NCR - no calibration required, VOU - verify on use

Section 8. Testing data

8.1 FCC 15.207(a) and RSS-Gen 8.8 AC power line conducted emissions limits

8.1.1 Definitions and limits

FCC:
Except as shown in paragraphs (b) and (c) of this section, for an intentional radiator that is designed to be connected to the public utility (AC) power line, the radio frequency voltage that is conducted back onto the AC power line on any frequency or frequencies, within the band 150 kHz to 30 MHz, shall not exceed the limits in the following table, as measured using a 50 µH/50 Ω line impedance stabilization network (LISN). Compliance with the provisions of this paragraph shall be based on the measurement of the radio frequency voltage between each power line and ground at the power terminal. The lower limit applies at the boundary between the frequency ranges.

IC:
A radio apparatus that is designed to be connected to the public utility (AC) power line shall ensure that the radio frequency voltage, which is conducted back onto the AC power line on any frequency or frequencies within the band 150 kHz to 30 MHz, shall not exceed the limits in table below.

Unless the requirements applicable to a given device state otherwise, for any radio apparatus equipped to operate from the public utility AC power supply either directly or indirectly (such as with a battery charger), the radio frequency voltage of emissions conducted back onto the AC power lines in the frequency range of 0.15 MHz to 30 MHz shall not exceed the limits shown in table below. The more stringent limit applies at the frequency range boundaries.

Table 8.1-1: *Conducted emissions limit*

Frequency of emission, MHz	Conducted limit, dBµV	
	Quasi-peak	Average**
0.15–0.5	66 to 56*	56 to 46*
0.5–5	56	46
5–30	60	50

Note: * - The level decreases linearly with the logarithm of the frequency.
** - A linear average detector is required.

8.1.2 Test summary

Test date	July 3, 2017	Temperature	23 °C
Test engineer	Paolo Barbieri	Air pressure	1009 mbar
Verdict	Pass	Relative humidity	42 %

8.1.3 Observations, settings and special notes

The EUT was set up as tabletop configuration.

The spectral scan has been corrected with transducer factors (i.e. cable loss, LISN factors, and attenuators) for determination of compliance.

A preview measurement was generated with the receiver in continuous scan mode. Emissions detected within 6 dB or above limit were re-measured with the appropriate detector against the correlating limit and recorded as the final measurement.

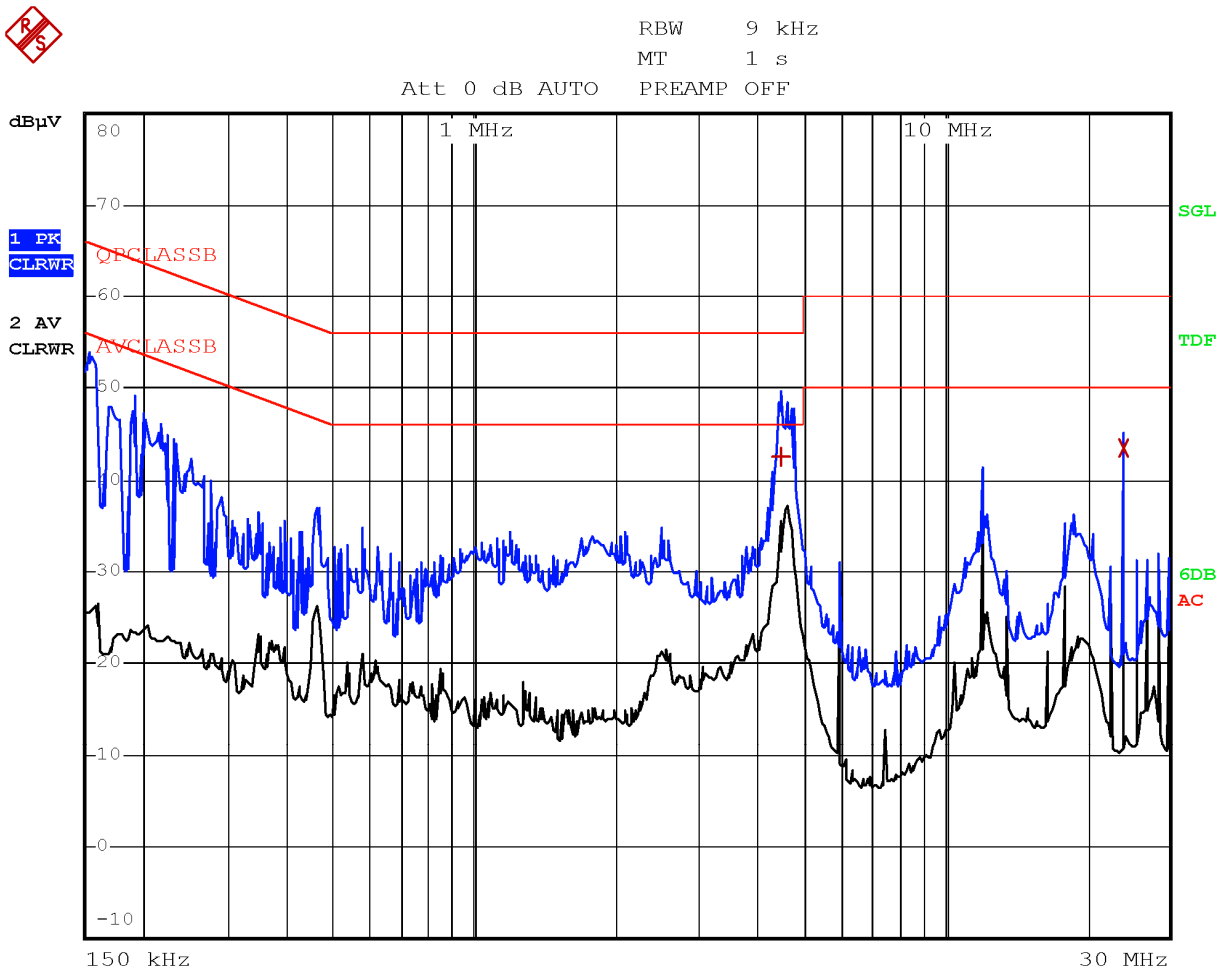
Receiver settings for preview measurements:

Resolution bandwidth	9 kHz
Detector mode	Peak and Average
Trace mode	Max Hold
Measurement time	10 ms

Receiver settings for final measurements:

Resolution bandwidth	9 kHz
Detector mode	Quasi-Peak and Average
Trace mode	Max Hold
Measurement time	1000 ms

8.1.4 Test data



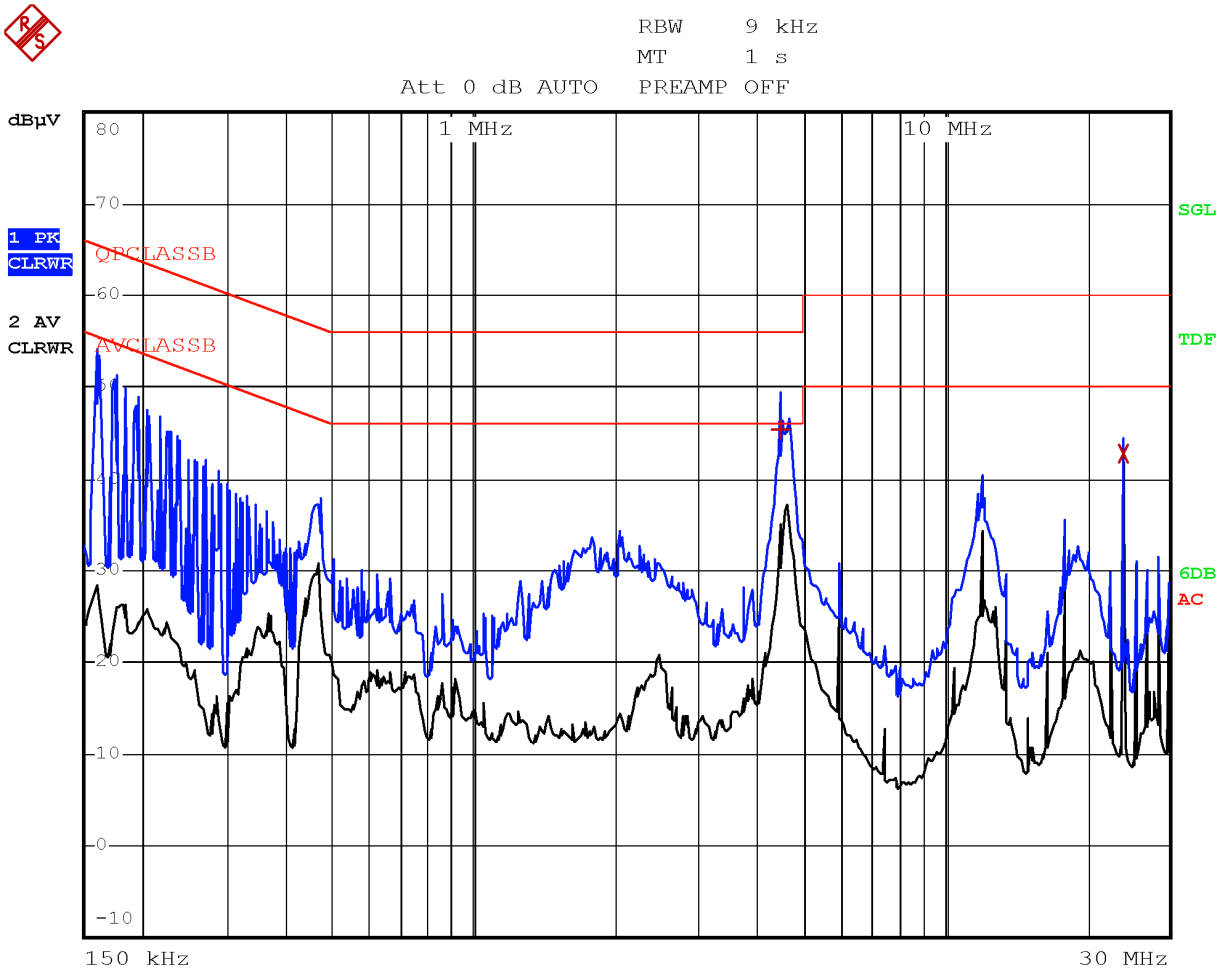
Plot 8.1-1: *Conducted emissions on phase line*

Table 8.1-2: *Quasi-Peak conducted emissions results on phase line*

Frequency, MHz	Q-Peak result, dBµV	Meas. Time, ms	Bandwidth, kHz	Filter	Correction, dB	Margin, dB	Limit, dBµV
4.5100	**42.6**	1000	9	EMI	10.8	**-13.4**	**56.0**

Table 8.1-3: *Average conducted emissions results on phase line*

Frequency, MHz	Average result, dBµV	Meas. Time, ms	Bandwidth, kHz	Filter	Correction, dB	Margin, dB	Limit, dBµV
24.0060	**43.6**	1000	9	EMI	15.1	**-6.4**	**50.0**



Plot 8.1-2: *Conducted emissions on neutral line*

Table 8.1-4: *Quasi-Peak conducted emissions results on neutral line*

Frequency, MHz	Q-Peak result, dBµV	Meas. Time, ms	Bandwidth, kHz	Filter	Correction, dB	Margin, dB	Limit, dBµV
4.5020	**45.5**	1000	9	EMI	10.8	**-10.5**	**56.0**

Table 8.1-5: *Average conducted emissions results on neutral line*

Frequency, MHz	Average result, dBµV	Meas. Time, ms	Bandwidth, kHz	Filter	Correction, dB	Margin, dB	Limit, dBµV
24.0060	**42.7**	1000	9	EMI	14.8	**-7.3**	**50.0**

8.2 FCC 15.247(a)(2) and RSS-247 5.2(a) Minimum 6 dB bandwidth for systems using digital modulation techniques

8.2.1 Definitions and limits

FCC and IC:

(a) Operation under the provisions of this Section is limited to frequency hopping and digitally modulated intentional radiators that comply with the following provisions:

(2) Systems using digital modulation techniques may operate in the 902–928 MHz, 2400–2483.5 MHz and 5725–5850 MHz bands. The minimum 6 dB bandwidth shall be at least 500 kHz.

8.2.2 Test summary

Test date	July 3, 2017	Temperature	23 °C
Test engineer	Paolo Barbieri	Air pressure	1009 mbar
Verdict	Pass	Relative humidity	42 %

8.2.3 Observations, settings and special notes

Spectrum analyser settings:

Resolution bandwidth	100 kHz
Video bandwidth	300 kHz
Frequency span	2 MHz
Detector mode	Peak
Trace mode	Max Hold

8.2.4 Test data

Table 8.2-1: *6 dB bandwidth results*

Modulation	Frequency, MHz	6 dB bandwidth, MHz	Limit, MHz	Margin, MHz
BLE	2402	0.700	0.50	0.200
	2440	0.708	0.50	0.208
	2480	0.688	0.50	0.188

Table 8.2-2: *99% bandwidth results*

Modulation	Frequency, MHz	6 dB bandwidth, MHz	Limit, MHz	Margin, MHz
BLE	2402	1.04	--	--
	2440	1.05	--	--
	2480	1.02	--	--

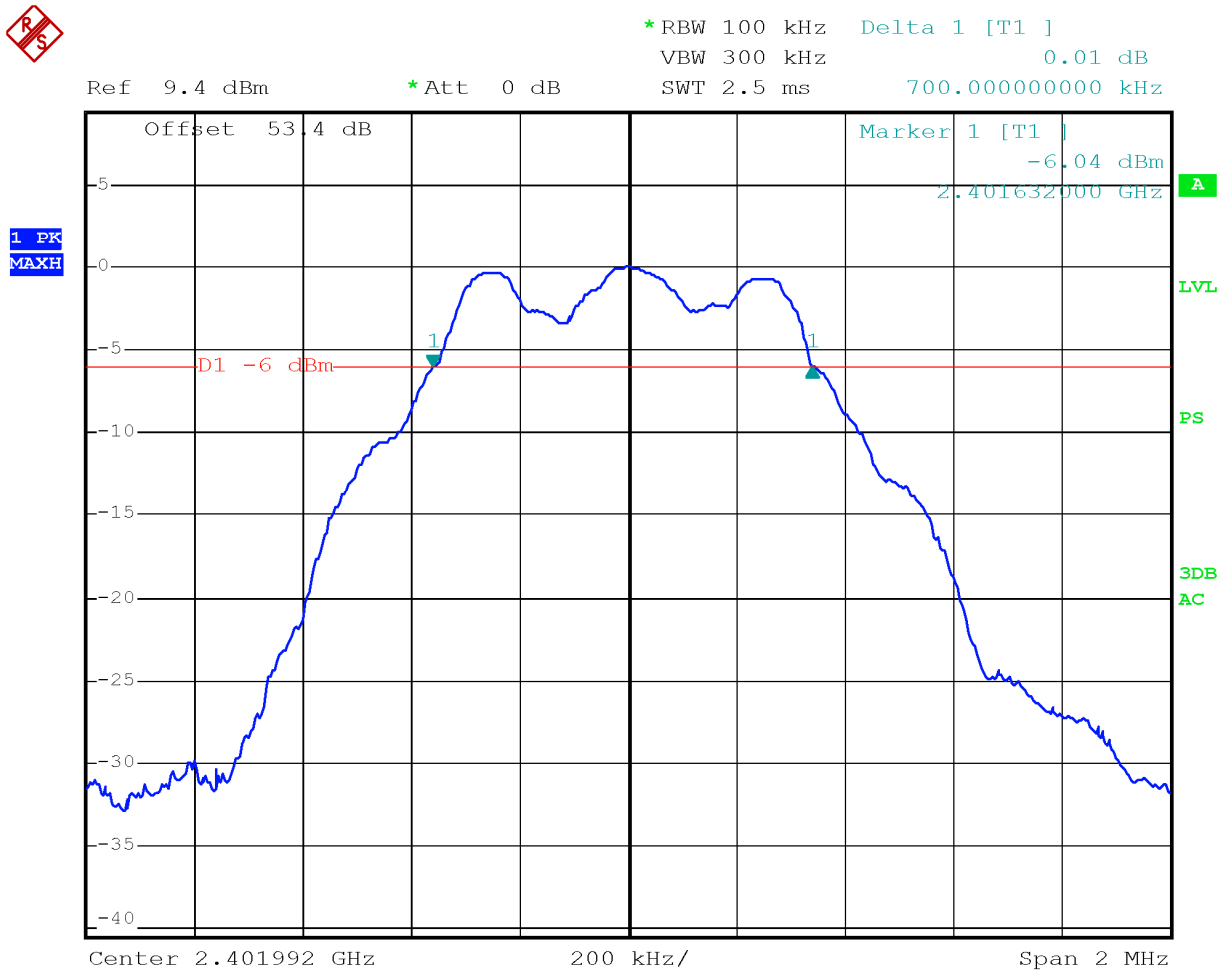


Figure 8.2-1: *6 dB bandwidth on CH 0, sample plot*

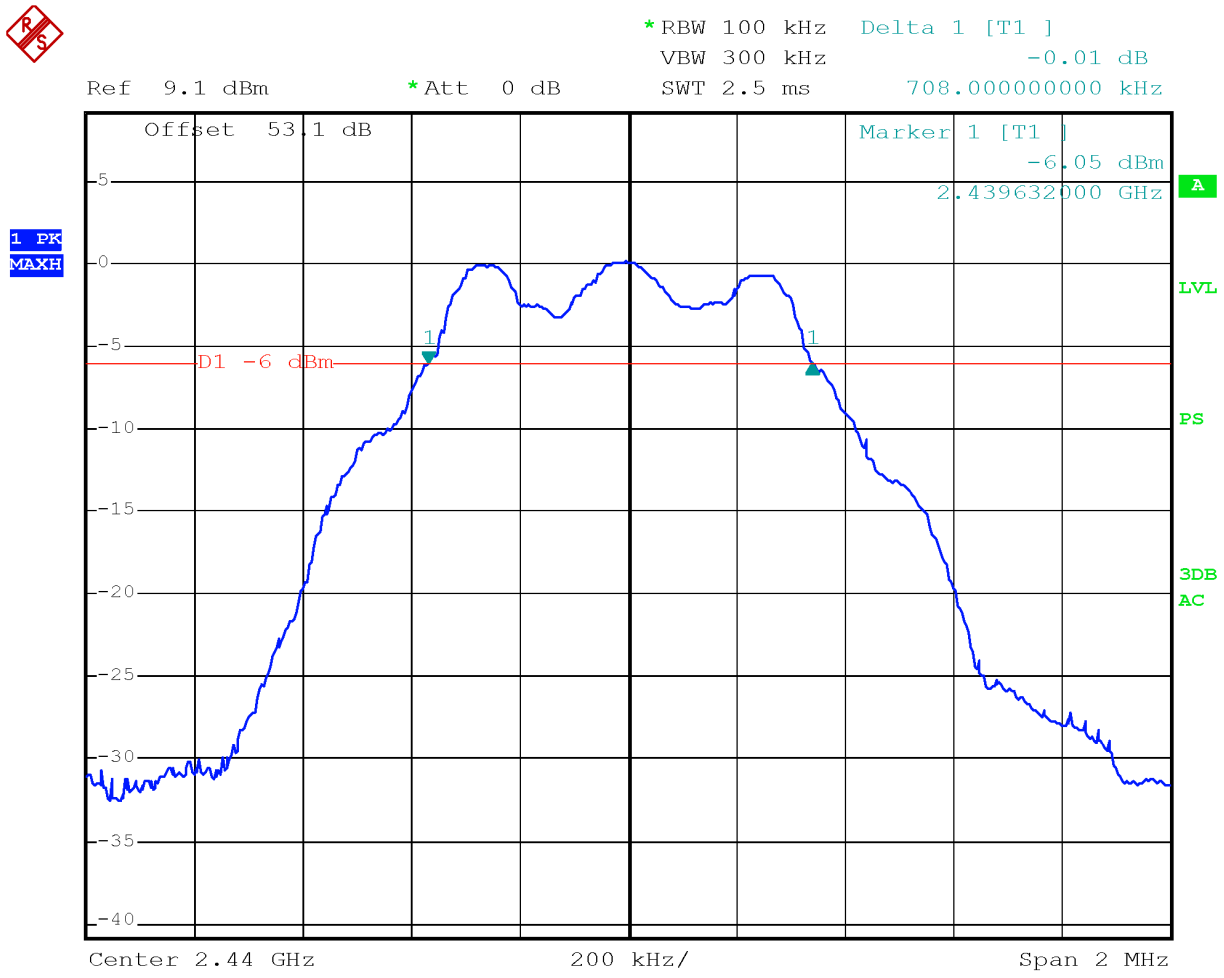


Figure 8.2-2: *6 dB bandwidth on CH 19, sample plot*

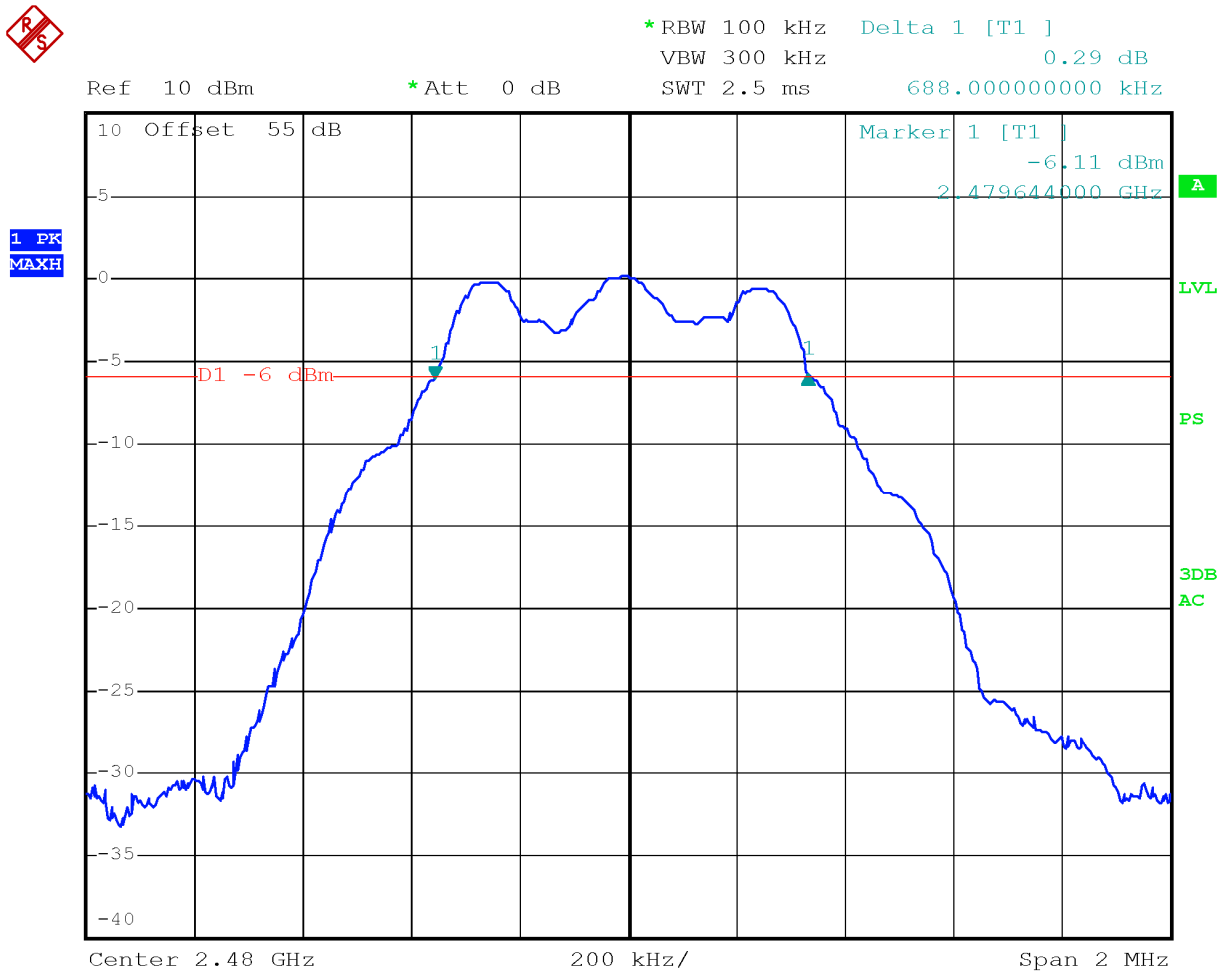


Figure 8.2-3: *6 dB bandwidth on CH 39, sample plot*

8.3 FCC 15.247(b) and RSS-247 5.4 (d) Transmitter output power and e.i.r.p. requirements

8.3.1 Definitions and limits

FCC:

(b) The maximum peak conducted output power of the intentional radiator shall not exceed the following:

(3) For systems using digital modulation in the 902–928 MHz, 2400–2483.5 MHz, and 5725–5850 MHz bands: 1 W (30 dBm). As an alternative to a peak power measurement, compliance with the one Watt limit can be based on a measurement of the maximum conducted output power. Maximum Conducted Output Power is defined as the total transmit power delivered to all antennas and antenna elements averaged across all symbols in the signaling alphabet when the transmitter is operating at its maximum power control level. Power must be summed across all antennas and antenna elements. The average must not include any time intervals during which the transmitter is off or is transmitting at a reduced power level. If multiple modes of operation are possible (e.g., alternative modulation methods), the maximum conducted output power is the highest total transmit power occurring in any mode.

(4) The conducted output power limit specified in paragraph (b) of this section is based on the use of antennas with directional gains that do not exceed 6 dBi. Except as shown in paragraph (c) of this section, if transmitting antennas of directional gain greater than 6 dBi are used, the conducted output power from the intentional radiator shall be reduced below the stated values in paragraphs (b)(1), (b)(2), and (b)(3) of this section, as appropriate, by the amount in dB that the directional gain of the antenna exceeds 6 dBi.

(i) Systems operating in the 2400–2483.5 MHz band that are used exclusively for fixed, point-to-point operations may employ transmitting antennas with directional gain greater than 6 dBi provided the maximum peak output power of the intentional radiator is reduced by 1 dB for every 3 dB that the directional gain of the antenna exceeds 6 dBi.

Fixed, point-to-point operation, as used in paragraphs (b)(3)(i) and (b)(3)(ii) of this section, excludes the use of point-to-multipoint systems, omnidirectional applications, and multiple co-located intentional radiators transmitting the same information. The operator of the spread spectrum intentional radiator or, if the equipment is professionally installed, the installer is responsible for ensuring that the system is used exclusively for fixed, point-to-point operations. The instruction manual furnished with the intentional radiator shall contain language in the installation instructions informing the operator and the installer of this responsibility.

(c) Operation with directional antenna gains greater than 6 dBi.

(2) In addition to the provisions in paragraphs (b)(1), (b)(3), (b)(4) and (c)(1)(i) of this section, transmitters operating in the 2400–2483.5 MHz band that emit multiple directional beams, simultaneously or sequentially, for the purpose of directing signals to individual receivers or to groups of receivers provided the emissions comply with the following:

(i) Different information must be transmitted to each receiver.

(ii) If the transmitter employs an antenna system that emits multiple directional beams but does not do emit multiple directional beams simultaneously, the total output power conducted to the array or arrays that comprise the device, i.e., the sum of the power supplied to all antennas, antenna elements, staves, etc. and summed across all carriers or frequency channels, shall not exceed the limit specified in paragraph (b)(1) or (b)(3) of this section, as applicable. However, the total conducted output power shall be reduced by 1 dB below the specified limits for each 3 dB that the directional gain of the antenna/antenna array exceeds 6 dBi. The directional antenna gain shall be computed as follows:

(A) The directional gain shall be calculated as the sum of 10 log (number of array elements or staves) plus the directional gain of the element or stave having the highest gain.

IC:

For DTSs employing digital modulation techniques operating in the bands 902–928 MHz and 2400–2483.5 MHz, the maximum peak conducted output power shall not exceed 1W. Except as provided in Section 5.4(5), the e.i.r.p. shall not exceed 4 W.

Fixed point-to-point systems in the bands 2400-2483.5 MHz and 5725-5850 MHz are permitted to have an e.i.r.p. higher than 4 W provided that the higher e.i.r.p. is achieved by employing higher gain directional antennas and not higher transmitter output powers. Point-to-multipoint systems, omnidirectional applications and multiple co-located transmitters transmitting the same information are prohibited from exceeding an e.i.r.p. of 4 W.

8.3.2 Test summary

Test date	July 3, 2017	Temperature	23 °C
Test engineer	Paolo Barbieri	Air pressure	1009 mbar
Verdict	Pass	Relative humidity	42 %

8.3.3 Observations, settings and special notes

The following procedure shall be used when an instrument with a resolution bandwidth that is greater than the DTS bandwidth is available to perform the measurement:
a) Set the RBW ≥ DTS bandwidth.
b) Set VBW ≥ [3 × RBW].
c) Set span ≥ [3 × RBW].
d) Sweep time = auto couple.
e) Detector = peak.
f) Trace mode = max hold.
g) Allow trace to fully stabilize.
h) Use peak marker function to determine the peak amplitude level.

8.3.4 Test data

Table 8.3-1: *Maximum peak conducted output power*

Modulation	Frequency, MHz	Conducted output power, dBm		Margin, dB	Antenna gain, dBi	EIRP, dBm	EIRP limit, dBm	EIRP margin, dB
		Level	Limit					
BLE	2402	3.0	30.0	-27.0	2.3	5.3	36.0	-30.7
	2440	2.9	30.0	-27.1	2.3	5.2	36.0	-38.8
	2480	2.6	30.0	-27.4	2.3	4.9	36.0	-31.1

8.4 FCC 15.247(d) and RSS-247 5.5 Spurious (out-of-band) emissions

8.4.1 Definitions and limits

FCC:
In any 100 kHz bandwidth outside the frequency band in which the spread spectrum or digitally modulated intentional radiator is operating, the radio frequency power that is produced by the intentional radiator shall be at least 20 dB below that in the 100 kHz bandwidth within the band that contains the highest level of the desired power, based on either an RF conducted or a radiated measurement, provided the transmitter demonstrates compliance with the peak conducted power limits. If the transmitter complies with the conducted power limits based on the use of RMS averaging over a time interval, as permitted under paragraph (b)(3) of this section, the attenuation required under this paragraph shall be 30 dB instead of 20 dB. Attenuation below the general limits specified in §15.209(a) is not required. In addition, radiated emissions which fall in the restricted bands, as defined in §15.205(a), must also comply with the radiated emission limits specified in §15.209(a) (see §15.205(c)).

IC:
In any 100 kHz bandwidth outside the frequency band in which the spread spectrum or digitally modulated device is operating, the RF power that is produced shall be at least 20 dB below that in the 100 kHz bandwidth within the band that contains the highest level of the desired power, based on either an RF conducted or a radiated measurement, provided that the transmitter demonstrates compliance with the peak conducted power limits. If the transmitter complies with the conducted power limits based on the use of root-mean-square averaging over a time interval, as permitted under Section 5.4(4), the attenuation required shall be 30 dB instead of 20 dB. Attenuation below the general field strength limits specified in RSS-Gen is not required.

Table 8.4-1: *FCC §15.209 and RSS-Gen – Radiated emission limits*

Frequency, MHz	Field strength of emissions		Measurement distance, m
	µV/m	dBµV/m	
0.009–0.490	2400/F	$67.6 - 20 \times \log_{10}(F)$	300
0.490–1.705	24000/F	$87.6 - 20 \times \log_{10}(F)$	30
1.705–30.0	30	29.5	30
30–88	100	40.0	3
88–216	150	43.5	3
216–960	200	46.0	3
above 960	500	54.0	3

Notes: In the emission table above, the tighter limit applies at the band edges.
For frequencies above 1 GHz the limit on peak RF emissions is 20 dB above the maximum permitted average emission limit applicable to the equipment under test

Table 8.4-2: *IC restricted frequency bands*

MHz	MHz	MHz	GHz
0.090–0.110	12.51975–12.52025	399.9–410	5.35–5.46
2.1735–2.1905	12.57675–12.57725	608–614	7.25–7.75
3.020–3.026	13.36–13.41	960–1427	8.025–8.5
4.125–4.128	16.42–16.423	1435–1626.5	9.0–9.2
4.17725–4.17775	16.69475–16.69525	1645.5–1646.5	9.3–9.5
4.20725–4.20775	16.80425–16.80475	1660–1710	10.6–12.7
5.677-5.683	25.5–25.67	1718.8–1722.2	13.25–13.4
6.215–6.218	37.5–38.25	2200–2300	14.47–14.5
6.26775–6.26825	73–74.6	2310–2390	15.35–16.2
6.31175–6.31225	74.8–75.2	2655–2900	17.7–21.4
8.291–8.294	108–138	3260–3267	22.01–23.12
8.362–8.366	156.52475–156.52525	3332–3339	23.6–24.0
8.37625–8.38675	156.7–156.9	3345.8–3358	31.2–31.8
8.41425–8.41475	240–285	3500–4400	36.43–36.5
12.29–12.293	322–335.4	4500–5150	Above 38.6

Note: Certain frequency bands listed in Table 8.4-2 and above 38.6 GHz are designated for low-power licence-exempt applications. These frequency bands and the requirements that apply to the devices are set out in this Standard

Table 8.4-3: *FCC restricted frequency bands*

MHz	MHz	MHz	GHz
0.090–0.110	16.42–16.423	399.9–410	4.5–5.15
0.495–0.505	16.69475–16.69525	608–614	5.35–5.46
2.1735–2.1905	16.80425–16.80475	960–1240	7.25–7.75
4.125–4.128	25.5–25.67	1300–1427	8.025–8.5
4.17725–4.17775	37.5–38.25	1435–1626.5	9.0–9.2
4.20725–4.20775	73–74.6	1645.5–1646.5	9.3–9.5
6.215–6.218	74.8–75.2	1660–1710	10.6–12.7
6.26775–6.26825	108–121.94	1718.8–1722.2	13.25–13.4
6.31175–6.31225	123–138	2200–2300	14.47–14.5
8.291–8.294	149.9–150.05	2310–2390	15.35–16.2
8.362–8.366	156.52475–156.52525	2483.5–2500	17.7–21.4
8.37625–8.38675	156.7–156.9	2690–2900	22.01–23.12
8.41425–8.41475	162.0125–167.17	3260–3267	23.6–24.0
12.29–12.293	167.72–173.2	3332–3339	31.2–31.8
12.51975–12.52025	240–285	3345.8–3358	36.43–36.5
12.57675–12.57725	322–335.4	3600–4400	Above 38.6
13.36–13.41			

8.4.2 Test summary

Test date	June 3, 2017	Temperature	23 °C
Test engineer	Paolo Barbieri	Air pressure	1009 mbar
Verdict	Pass	Relative humidity	42 %

8.4.3 Observations, settings and special notes

The spectrum was searched from 30 MHz to the 10th harmonic.
EUT was set to transmit with 100 % duty cycle.
Radiated measurements were performed at a distance of 3 m.

Spectrum analyser settings for radiated measurements within restricted bands below 1 GHz:

Resolution bandwidth:	100 kHz
Video bandwidth:	300 kHz
Detector mode:	Peak
Trace mode:	Max Hold

Spectrum analyser settings for peak radiated measurements within restricted bands above 1 GHz:

Resolution bandwidth:	1 MHz
Video bandwidth:	3 MHz
Detector mode:	Peak
Trace mode:	Max Hold

Spectrum analyser settings for average radiated measurements within restricted bands above 1 GHz:

Resolution bandwidth:	1 MHz
Video bandwidth:	10 Hz
Detector mode:	Peak
Trace mode:	Max Hold

8.4.4 Test data

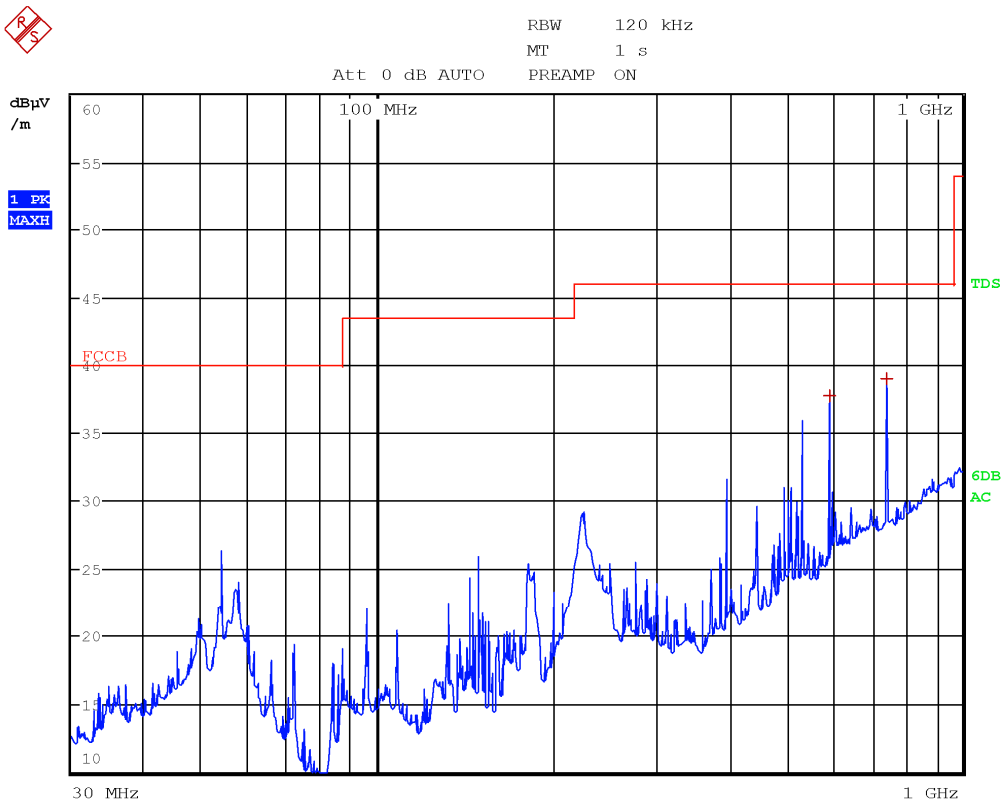


Figure 8.4-1: *Radiated spurious emissions for frequency range 30 MHz to 1 GHz with antenna in horizontal polarization, low channel*

Channel	Frequency, MHz	Quasi-Peak Field strength, dBµV/m		Margin, dB
		Measured	Limit	
Low	594.0300	37.8	46.0	-8.2
Low	742.5300	39.0	46.0	-7.0

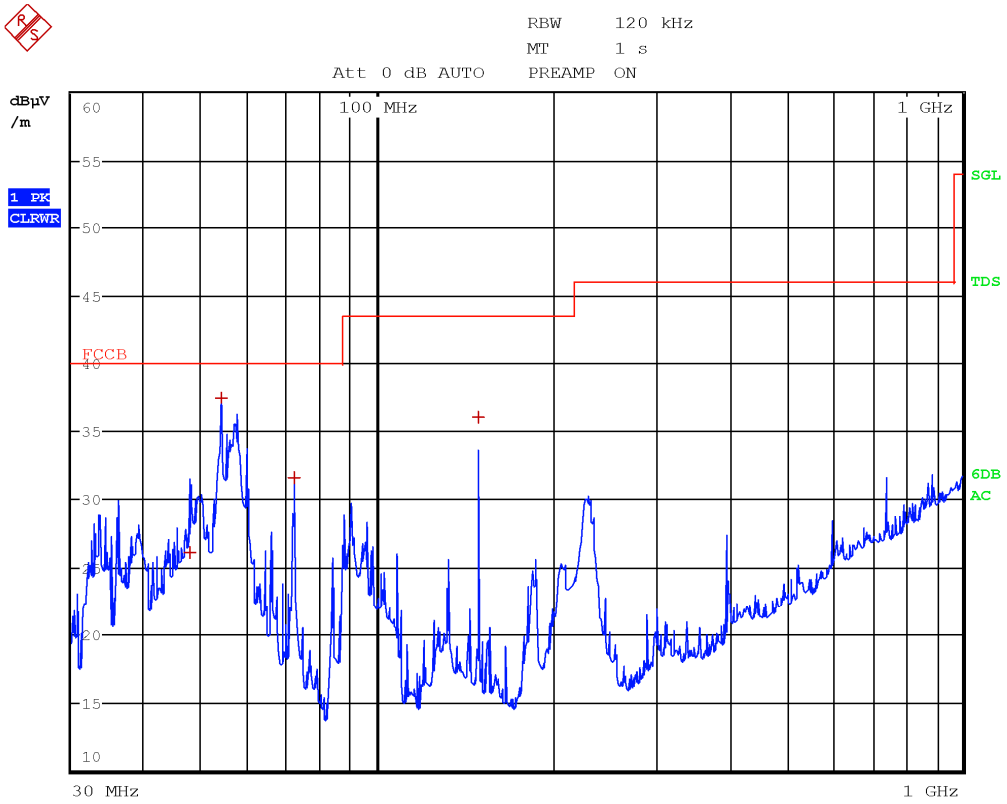


Figure 8.4-2: *Radiated spurious emissions for frequency range 30 MHz to 1 GHz with antenna in vertical polarization, low channel*

Channel	Frequency, MHz	Quasi-Peak Field strength, dBµV/m		Margin, dB
		Measured	Limit	
Low	47.9250	26.2	40.0	-13.8
Low	54.0000	37.5	40.0	-2.5
Low	72.0000	31.5	40.0	-8.5
Low	148.4750	36.0	43.5	-7.5

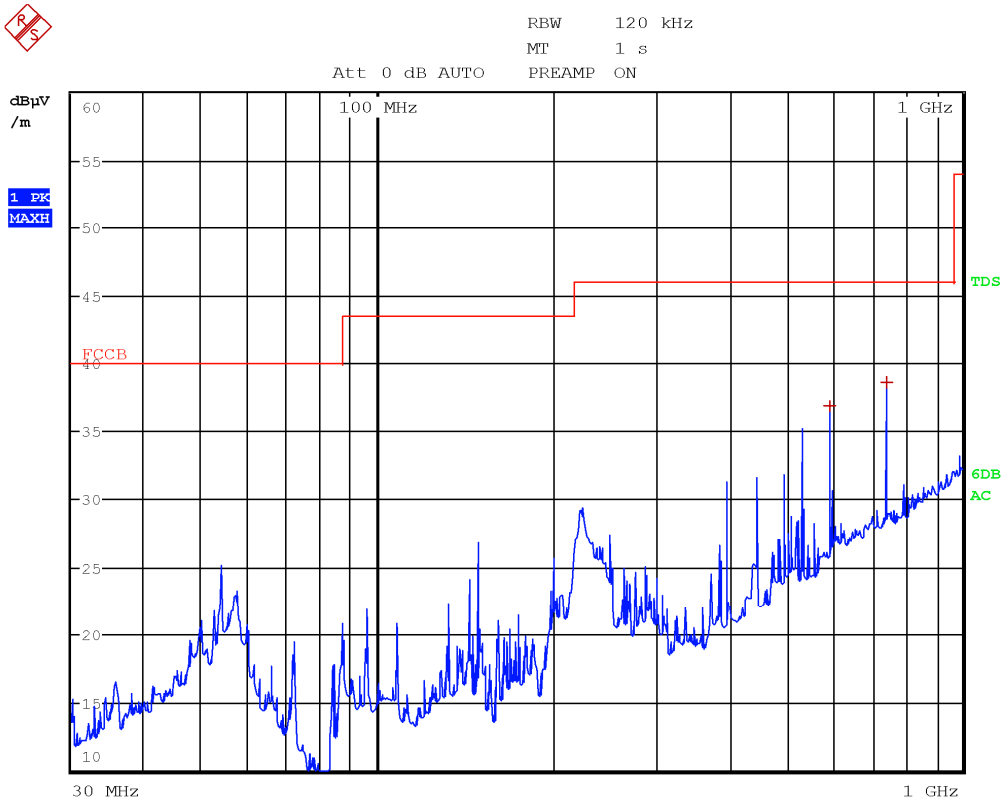


Figure 8.4-3: *Radiated spurious emissions for frequency range 30 MHz to 1 GHz with antenna in horizontal polarization, mid channel*

Channel	Frequency, MHz	Quasi-Peak Field strength, dBµV/m		Margin, dB
		Measured	Limit	
Mid	594.0300	36.8	46.0	-9.2
Mid	742.5300	38.6	46.0	-7.4

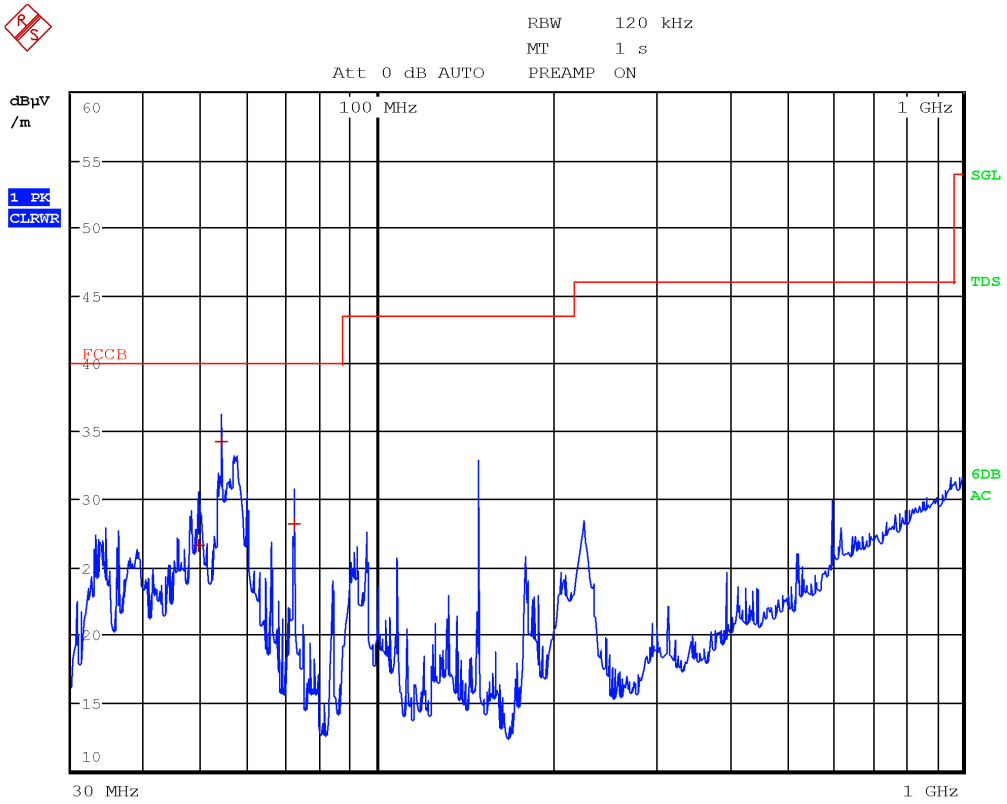


Figure 8.4-4: *Radiated spurious emissions for frequency range 30 MHz to 1 GHz with antenna in vertical polarization, mid channel*

Channel	Frequency, MHz	Quasi-Peak Field strength, dBµV/m		Margin, dB
		Measured	Limit	
Mid	49.5250	26.7	40.0	-13.3
Mid	54.0000	34.2	40.0	-5.8
Mid	72.0000	28.2	40.0	-11.8

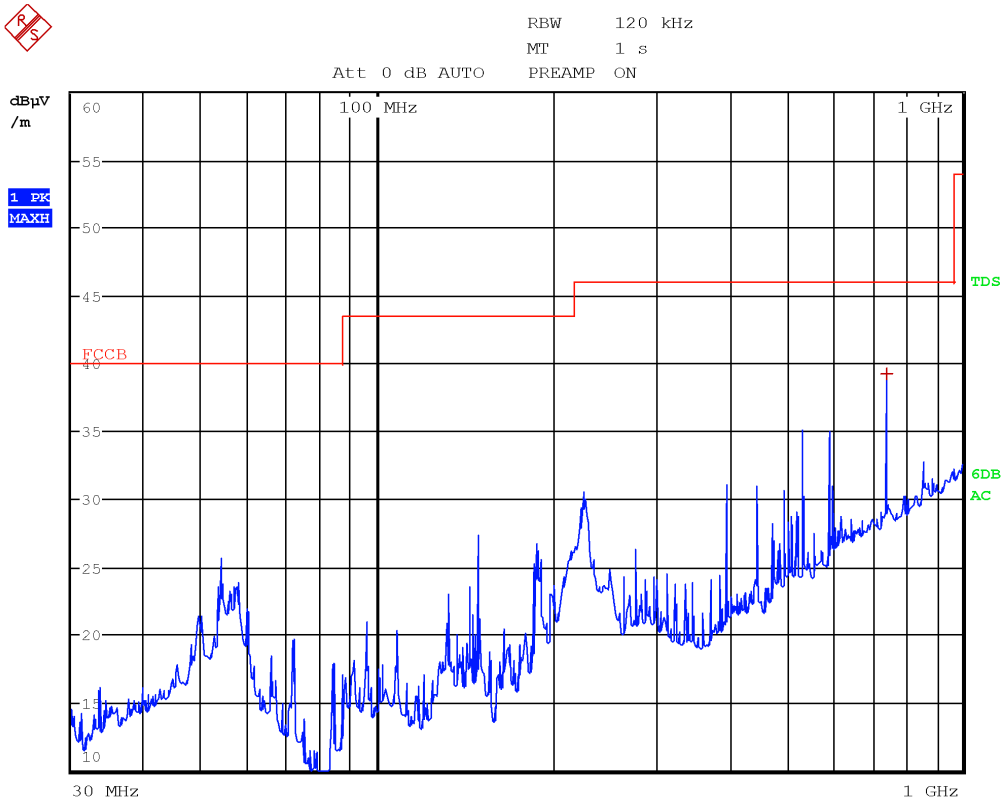


Figure 8.4-5: *Radiated spurious emissions for frequency range 30 MHz to 1 GHz with antenna in horizontal polarization, high channel*

Channel	Frequency, MHz	Quasi-Peak Field strength, dBµV/m		Margin, dB
		Measured	Limit	
High	742.5300	39.2	46.0	-6.8

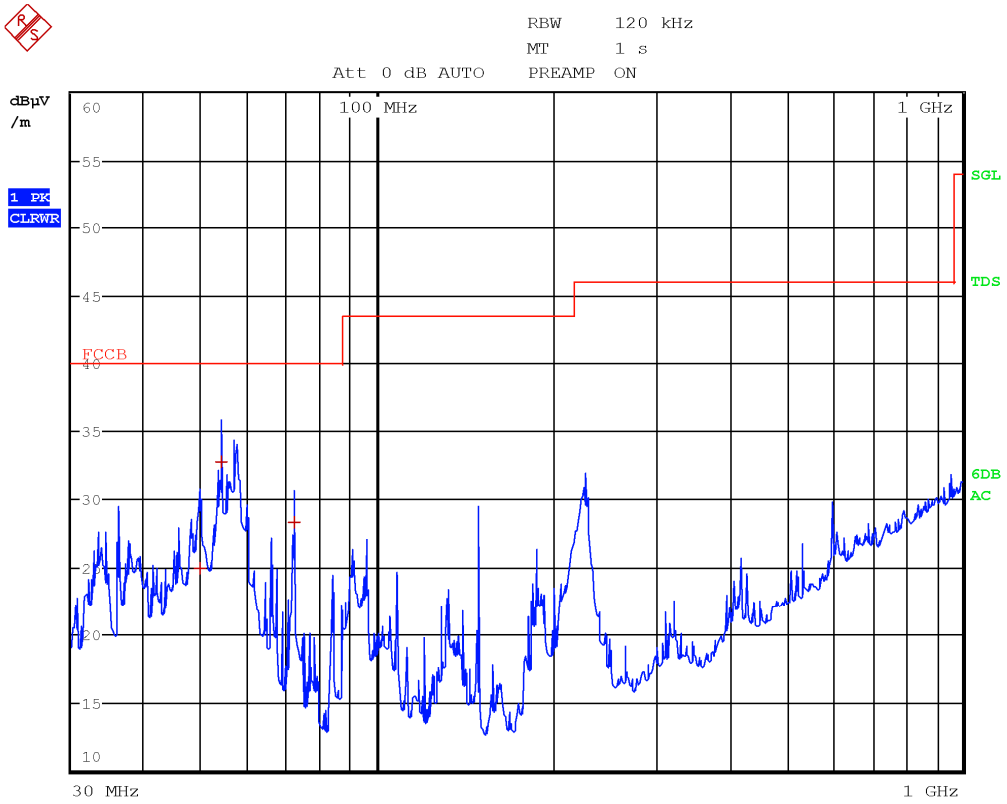


Figure 8.4-6: *Radiated spurious emissions for frequency range 30 MHz to 1 GHz with antenna in vertical polarization, high channel*

Channel	Frequency, MHz	Quasi-Peak Field strength, dBµV/m		Margin, dB
		Measured	Limit	
High	49.6000	25.0	40.0	-15.0
High	53.9750	32.7	40.0	-7.3
High	72.0250	28.3	40.0	-11.7

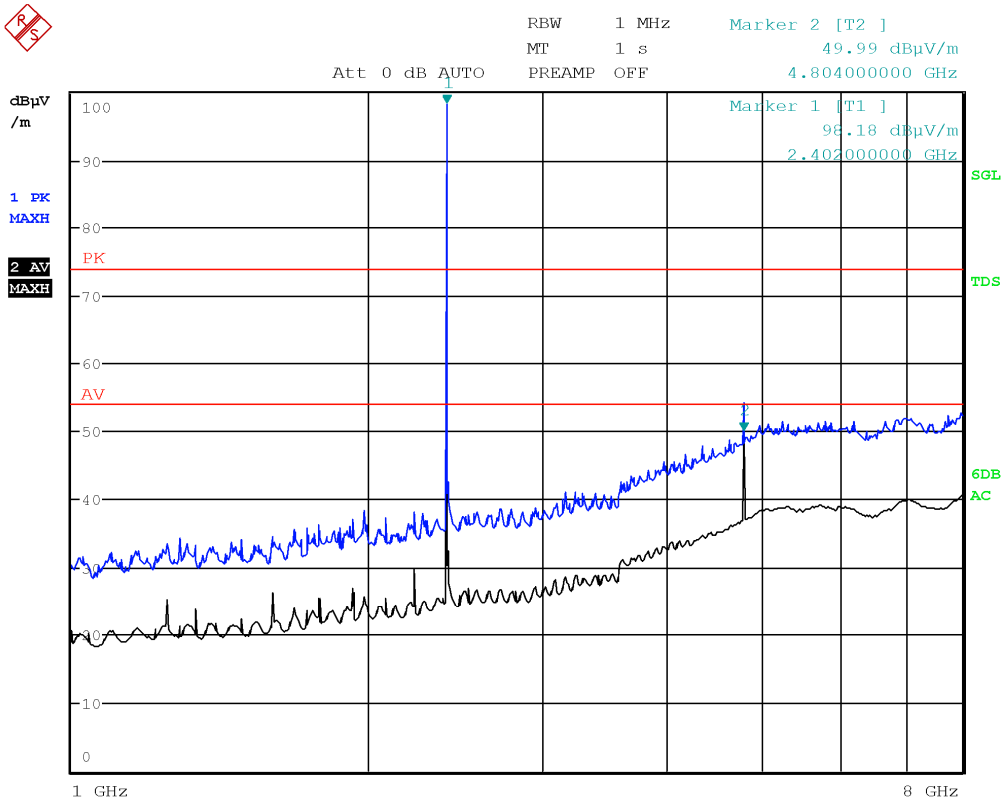


Figure 8.4-7: *Radiated spurious emissions for frequency range 1 GHz to 8 GHz with antenna in horizontal polarization, low channel*

Channel	Frequency, MHz	Peak Field strength, dBµV/m		Margin, dB	Average Field strength, dBµV/m		Margin, dB
		Measured	Limit		Measured	Limit	
Low	4804.0	54.1	74.0	-19.9	50.0	54.0	-4.0

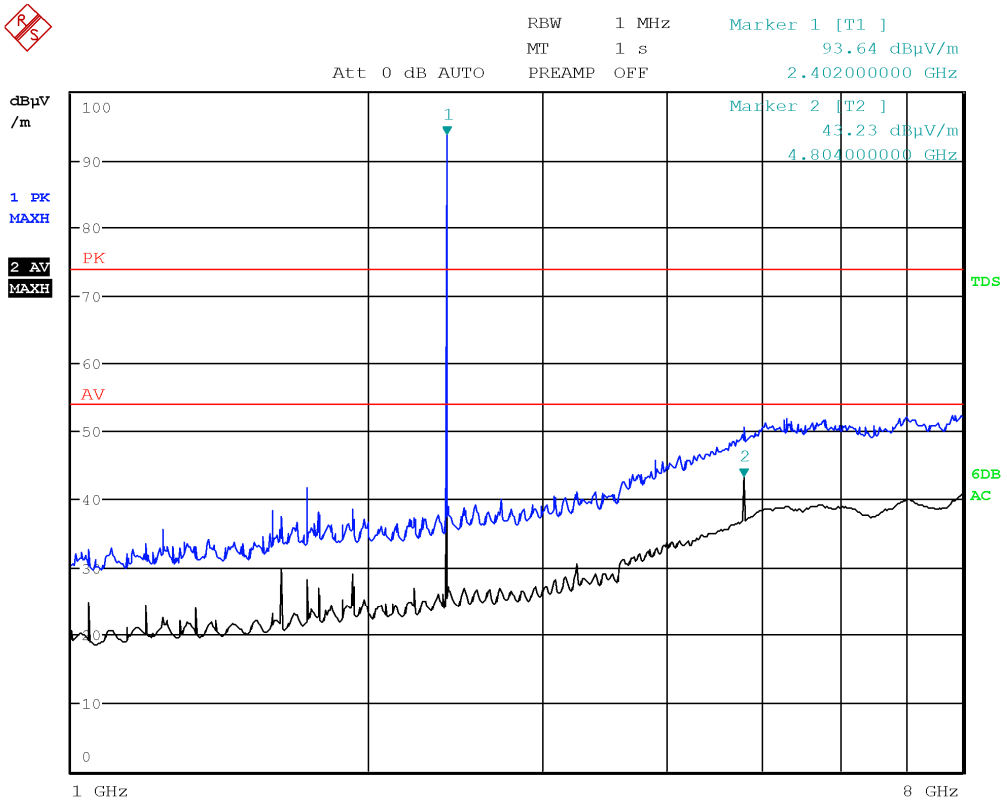


Figure 8.4-8: *Radiated spurious emissions for frequency range 1 GHz to 8 GHz with antenna in vertical polarization, low channel*

Channel	Frequency, MHz	Peak Field strength, dBµV/m		Margin, dB	Average Field strength, dBµV/m		Margin, dB
		Measured	Limit		Measured	Limit	
Low	4804.0	51.4	74.00	-22.6	43.3	54.00	-10.7

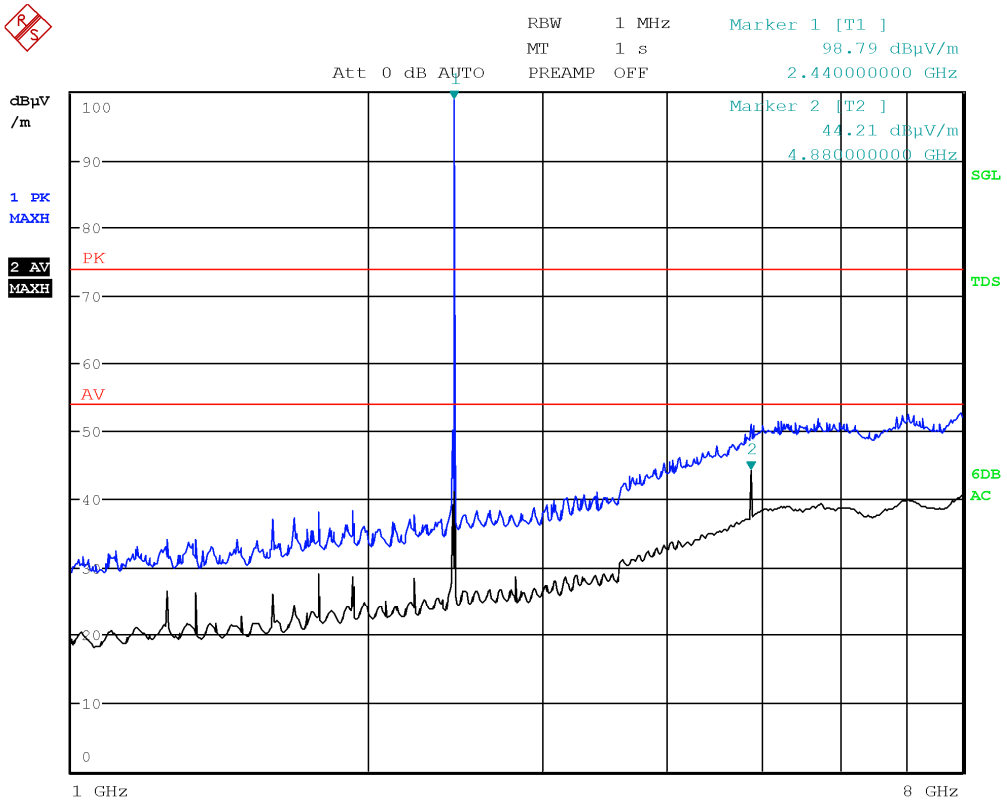


Figure 8.4-9: *Radiated spurious emissions for frequency range 1 GHz to 8 GHz with antenna in horizontal polarization, mid channel*

Channel	Frequency, MHz	Peak Field strength, dBµV/m		Margin, dB	Average Field strength, dBµV/m		Margin, dB
		Measured	Limit		Measured	Limit	
Mid	4880.0	51.5	74.00	-22.5	44.2	54.00	-9.8

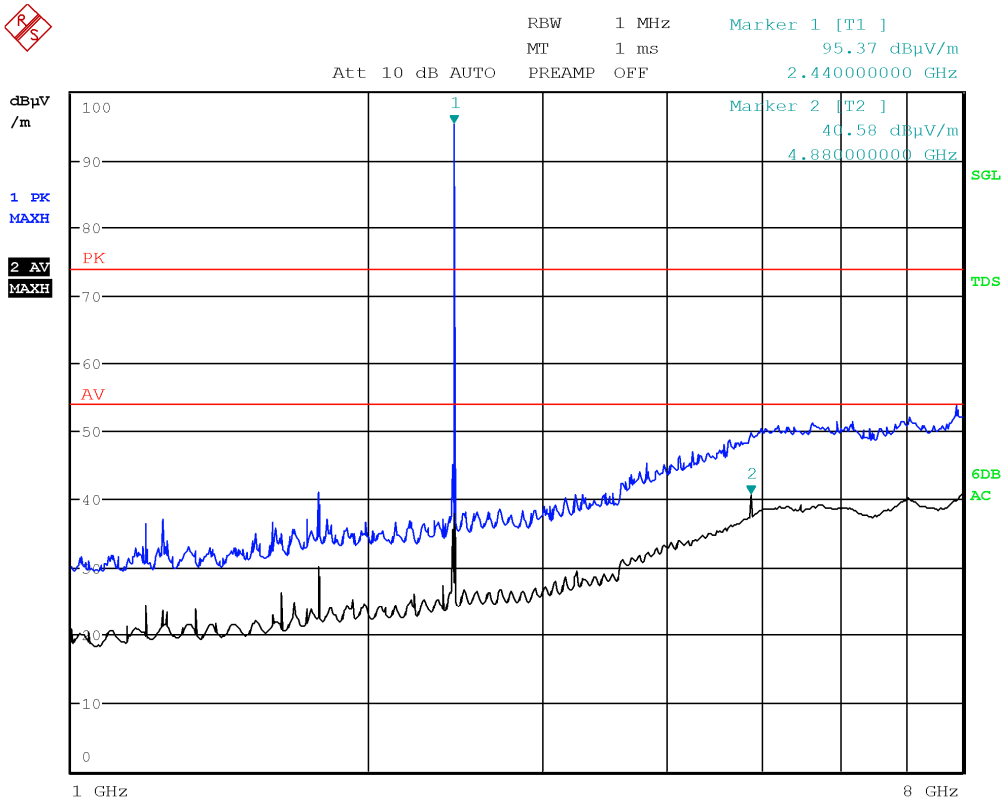


Figure 8.4-10: *Radiated spurious emissions for frequency range 1 GHz to 8 GHz with antenna in vertical polarization, mid channel*

Channel	Frequency, MHz	Peak Field strength, dBµV/m		Margin, dB	Average Field strength, dBµV/m		Margin, dB
		Measured	Limit		Measured	Limit	
Mid	4880.0	49.9	74.00	-24.1	40.6	54.00	-13.4

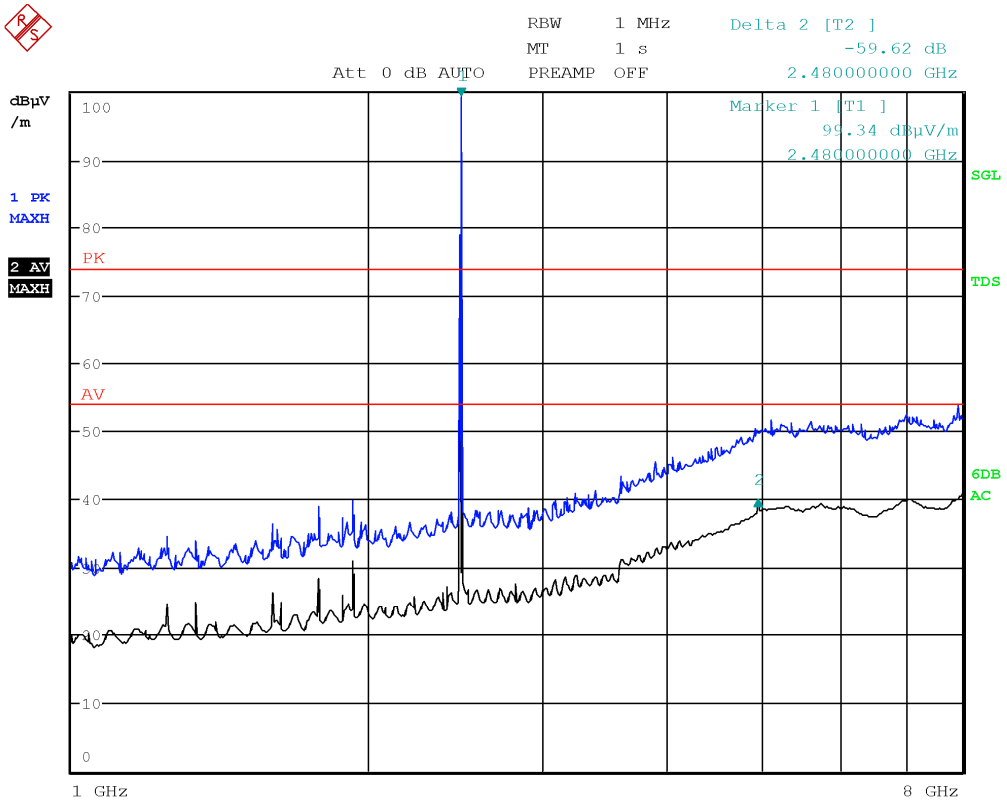


Figure 8.4-11: *Radiated spurious emissions for frequency range 1 GHz to 8 GHz with antenna in horizontal polarization, high channel*

Channel	Frequency, MHz	Peak Field strength, dBµV/m		Margin, dB	Average Field strength, dBµV/m		Margin, dB
		Measured	Limit		Measured	Limit	
High	4960.0	50.4	74.00	-23.6	39.7	54.00	-14.3

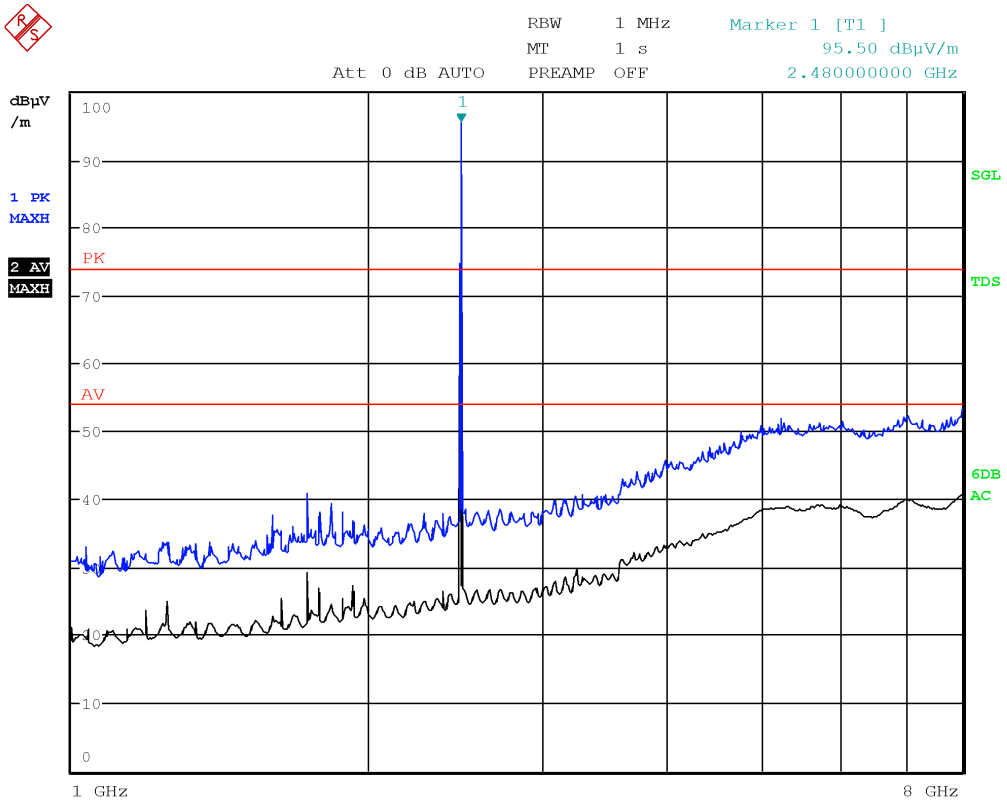


Figure 8.4-12: *Radiated spurious emissions for frequency range 1 GHz to 8 GHz with antenna in vertical polarization, high channel*

Channel	Frequency, MHz	Peak Field strength, dBµV/m		Margin, dB	Average Field strength, dBµV/m		Margin, dB
		Measured	Limit		Measured	Limit	
High	No spurious detected						

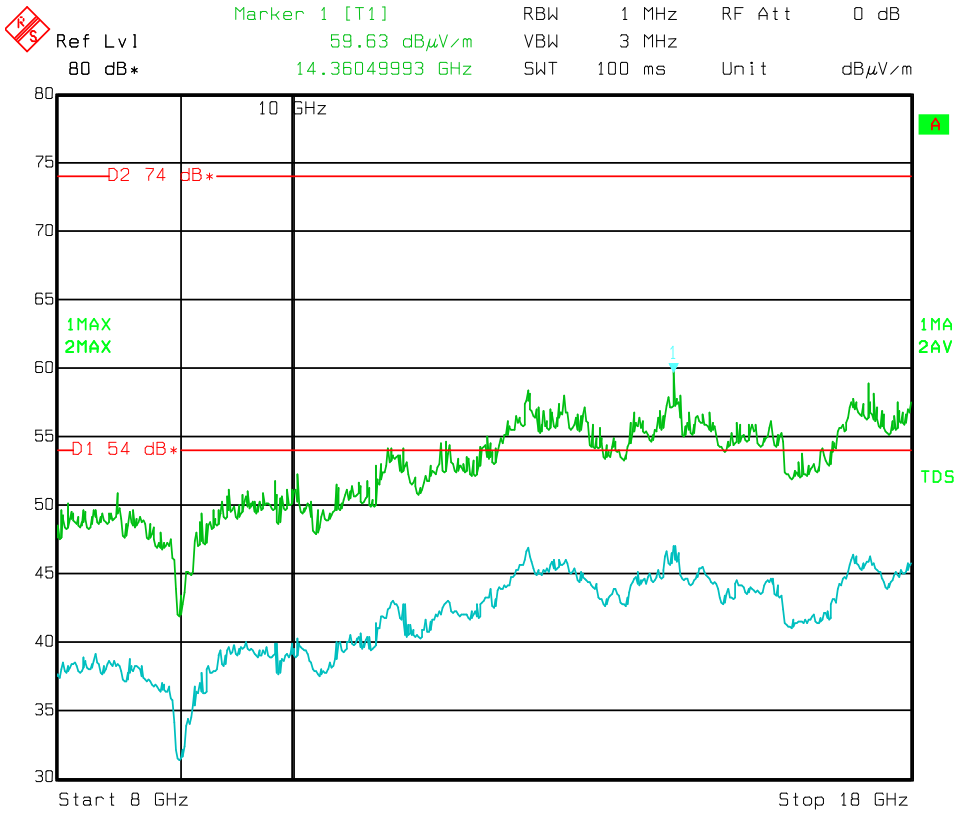


Figure 8.4-13: *Radiated spurious emissions for frequency range 8 GHz to 18 GHz with antenna in horizontal polarization, low channel*

Channel	Frequency, MHz	Peak Field strength, dBµV/m		Margin, dB	Average Field strength, dBµV/m		Margin, dB
		Measured	Limit		Measured	Limit	
Low	No spurious detected						

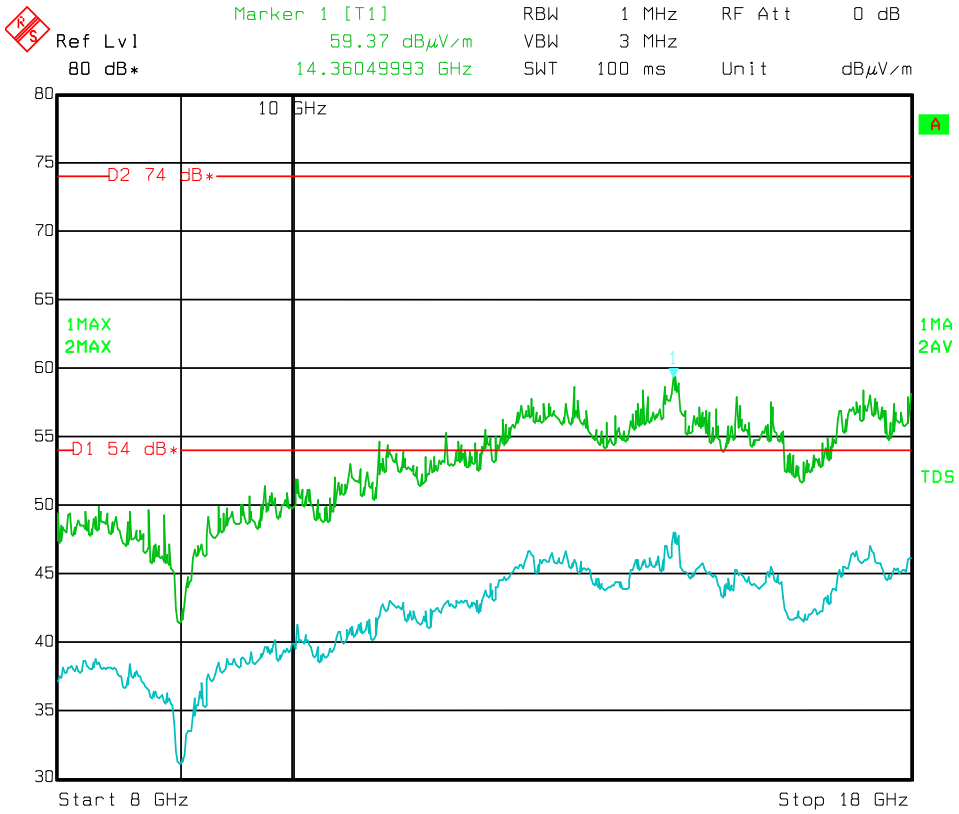


Figure 8.4-14: *Radiated spurious emissions for frequency range 8 GHz to 18 GHz with antenna in vertical polarization, low channel*

Channel	Frequency, MHz	Peak Field strength, dBµV/m		Margin, dB	Average Field strength, dBµV/m		Margin, dB
		Measured	Limit		Measured	Limit	
Low	No spurious detected						

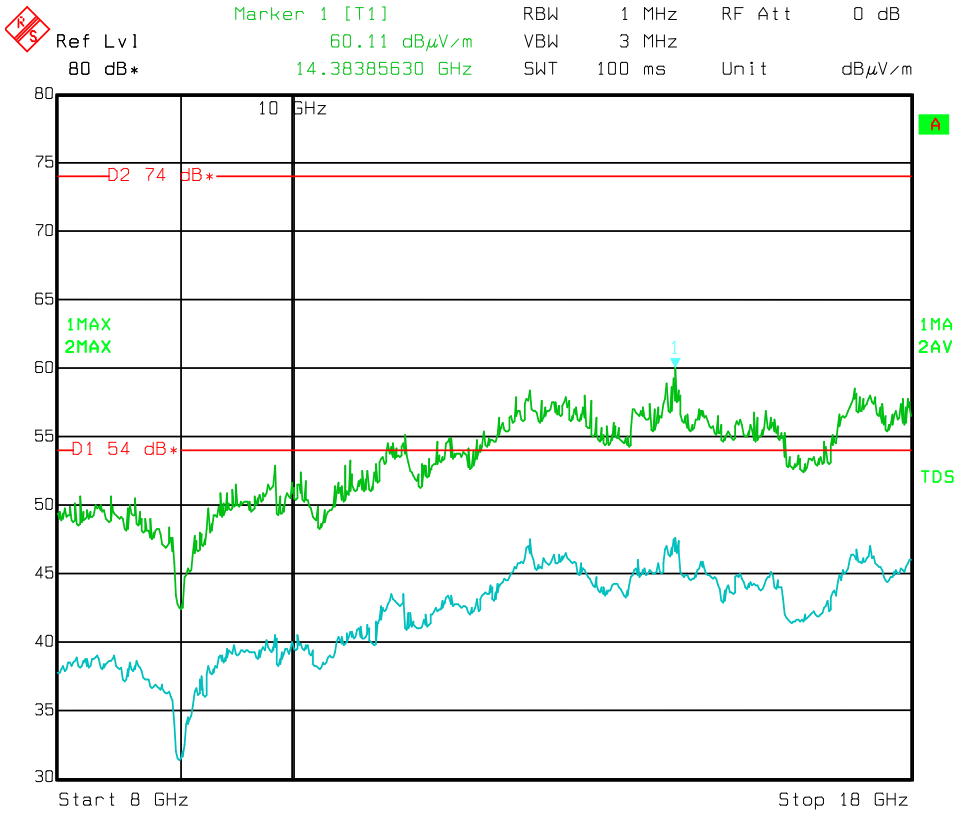


Figure 8.4-15: *Radiated spurious emissions for frequency range 8 GHz to 18 GHz with antenna in horizontal polarization, mid channel*

Channel	Frequency, MHz	Peak Field strength, dBµV/m		Margin, dB	Average Field strength, dBµV/m		Margin, dB
		Measured	Limit		Measured	Limit	
Mid	No spurious detected						

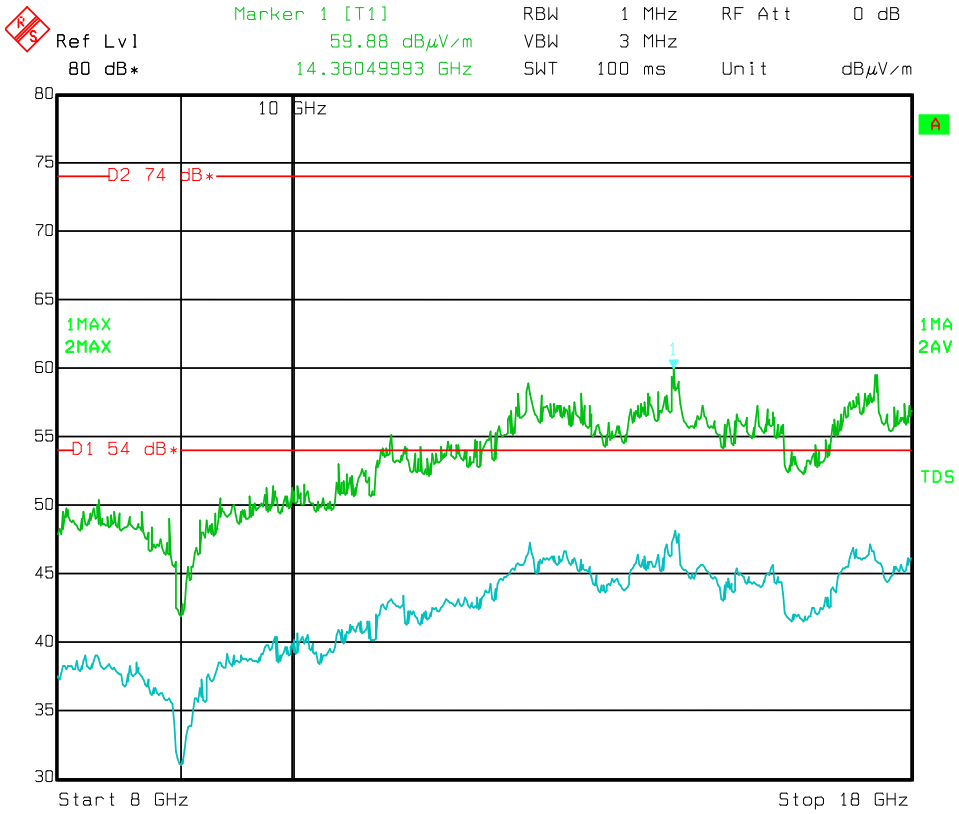


Figure 8.4-16: *Radiated spurious emissions for frequency range 8 GHz to 18 GHz with antenna in vertical polarization, mid channel*

Channel	Frequency, MHz	Peak Field strength, dBµV/m		Margin, dB	Average Field strength, dBµV/m		Margin, dB
		Measured	Limit		Measured	Limit	
Mid	No spurious detected						

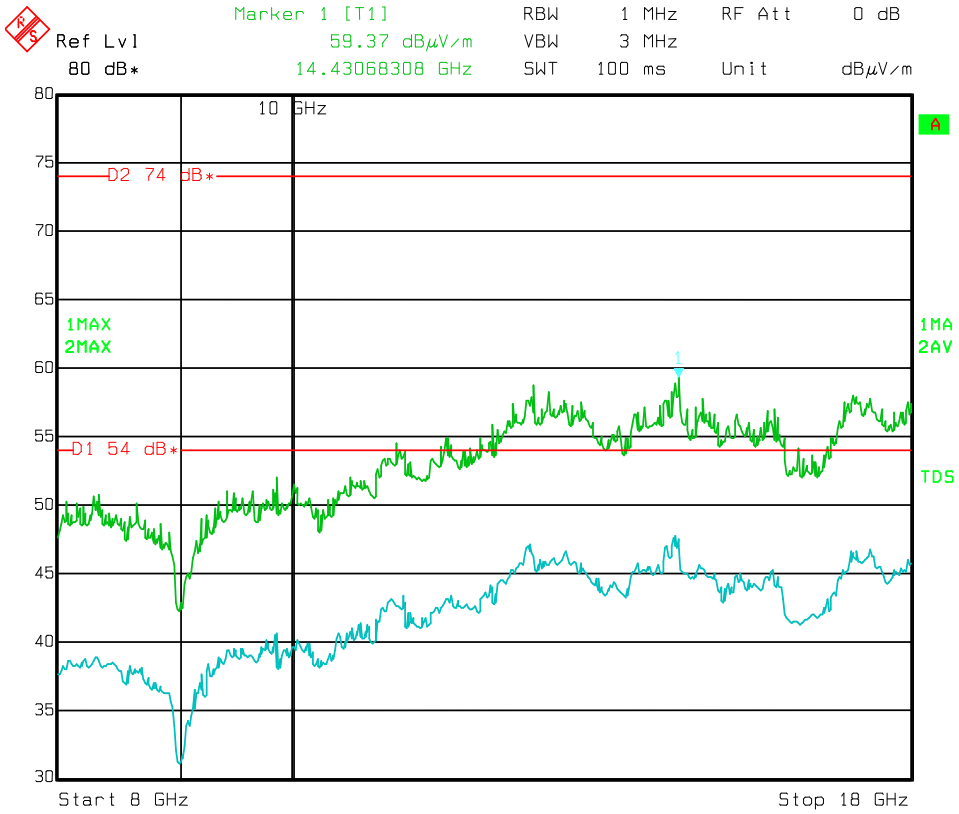


Figure 8.4-17: *Radiated spurious emissions for frequency range 8 GHz to 18 GHz with antenna in horizontal polarization, high channel*

Channel	Frequency, MHz	Peak Field strength, dBµV/m		Margin, dB	Average Field strength, dBµV/m		Margin, dB
		Measured	Limit		Measured	Limit	
High	No spurious detected						

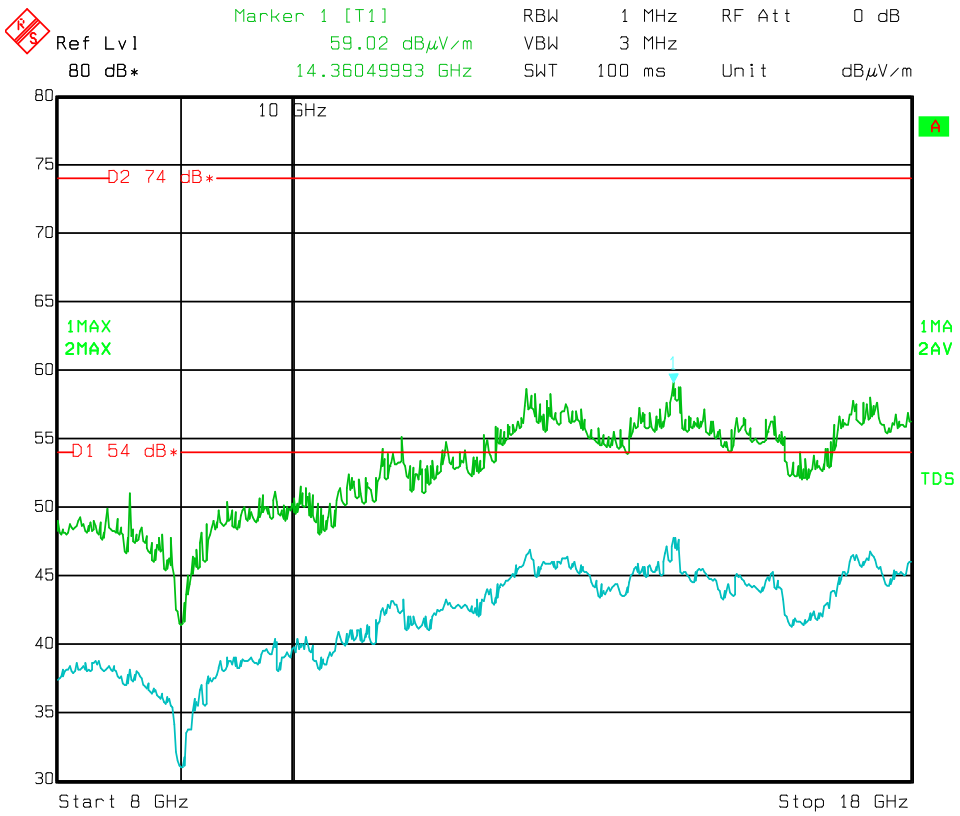


Figure 8.4-18: *Radiated spurious emissions for frequency range 8 GHz to 18 GHz with antenna in vertical polarization, high channel*

Channel	Frequency, MHz	Peak Field strength, dBµV/m		Margin, dB	Average Field strength, dBµV/m		Margin, dB
		Measured	Limit		Measured	Limit	
High	No spurious detected						

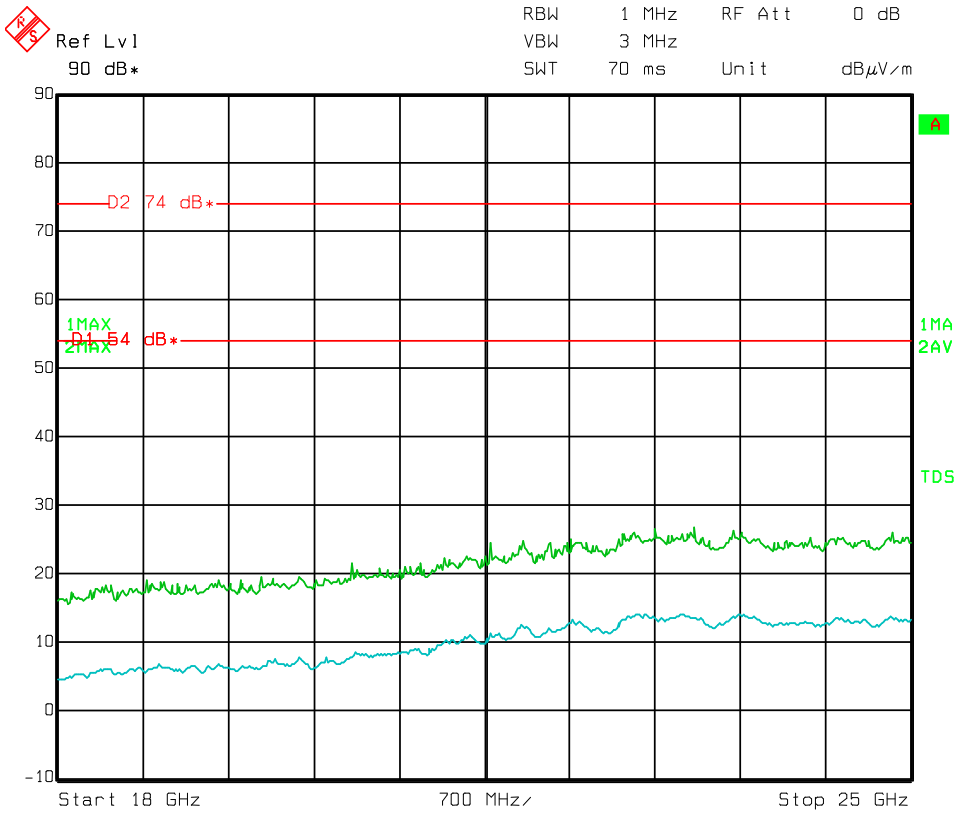


Figure 8.4-19: *Radiated spurious emissions for frequency range 18 GHz to 25 GHz with antenna in horizontal polarization, low channel*

Channel	Frequency, MHz	Peak Field strength, dBµV/m		Margin, dB	Average Field strength, dBµV/m		Margin, dB
		Measured	Limit		Measured	Limit	
Low	No spurious detected						

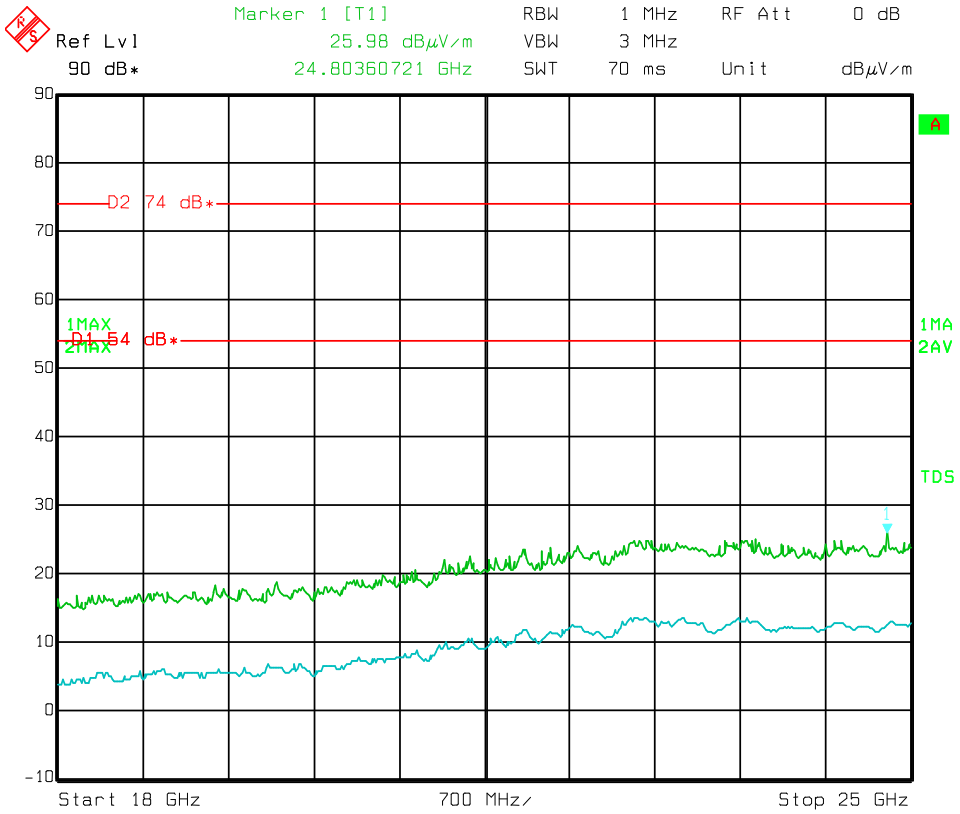


Figure 8.4-20: *Radiated spurious emissions for frequency range 18 GHz to 25 GHz with antenna in vertical polarization, low channel*

Channel	Frequency, MHz	Peak Field strength, dBµV/m		Margin, dB	Average Field strength, dBµV/m		Margin, dB
		Measured	Limit		Measured	Limit	
Low	No spurious detected						

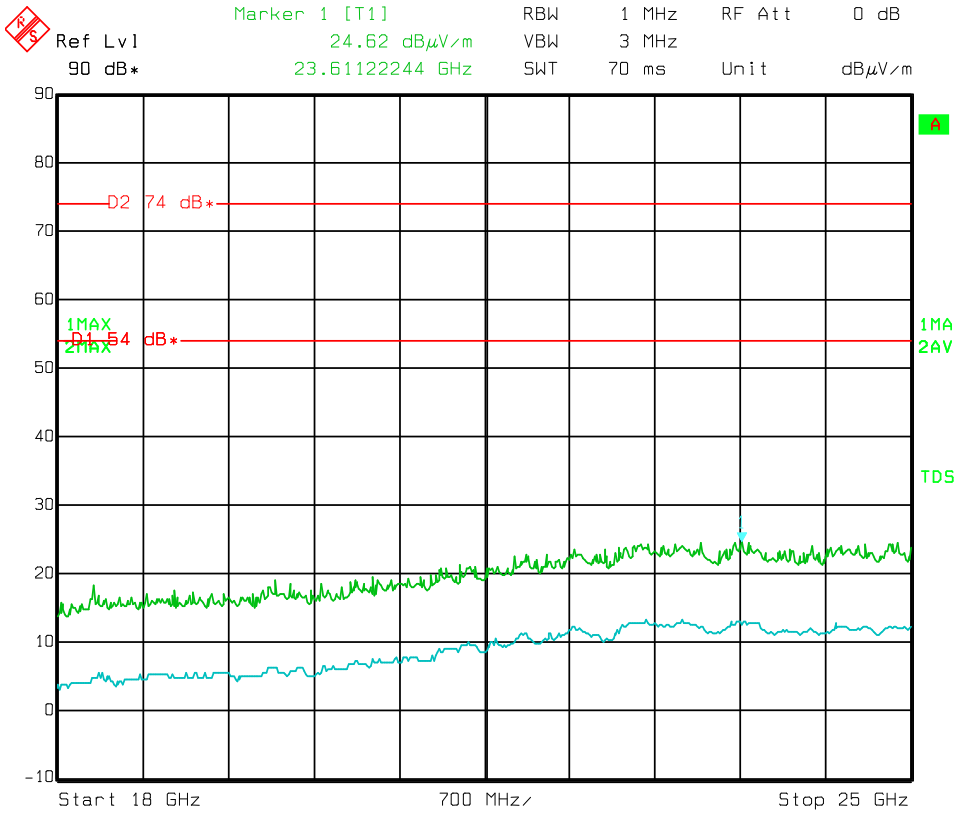


Figure 8.4-21: *Radiated spurious emissions for frequency range 18 GHz to 25 GHz with antenna in horizontal polarization, mid channel*

Channel	Frequency, MHz	Peak Field strength, dBµV/m		Margin, dB	Average Field strength, dBµV/m		Margin, dB
		Measured	Limit		Measured	Limit	
Mid	No spurious detected						

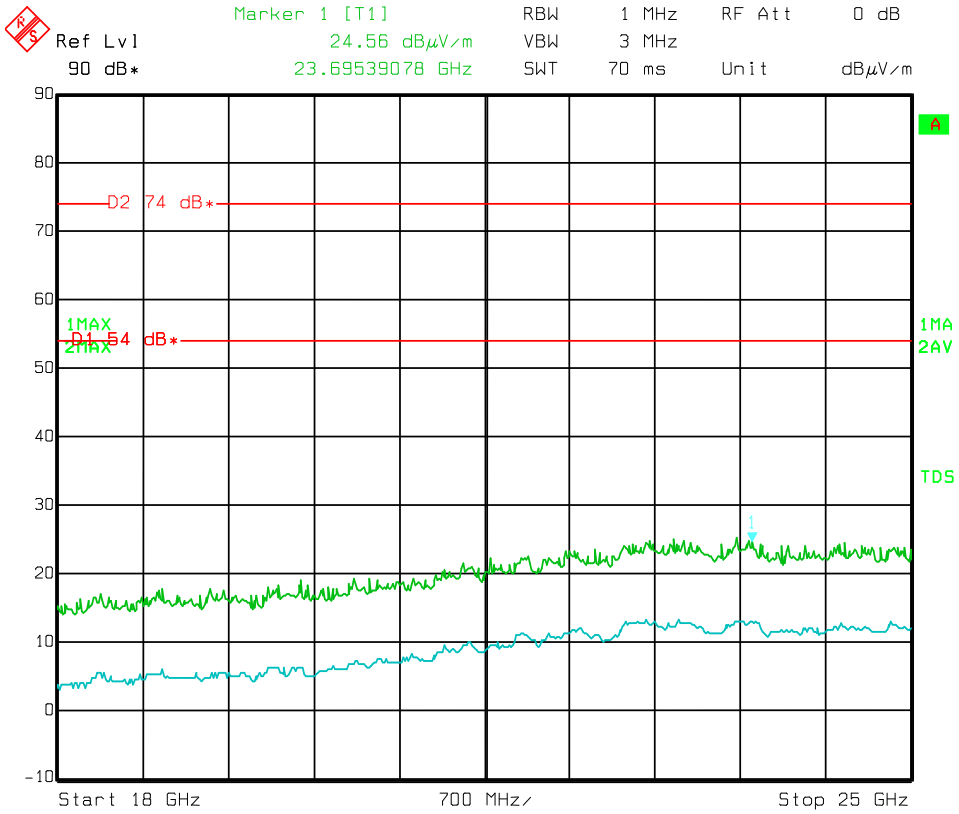


Figure 8.4-22: *Radiated spurious emissions for frequency range 18 GHz to 25 GHz with antenna in vertical polarization, mid channel*

Channel	Frequency, MHz	Peak Field strength, dBµV/m		Margin, dB	Average Field strength, dBµV/m		Margin, dB
		Measured	Limit		Measured	Limit	
Mid	No spurious detected						

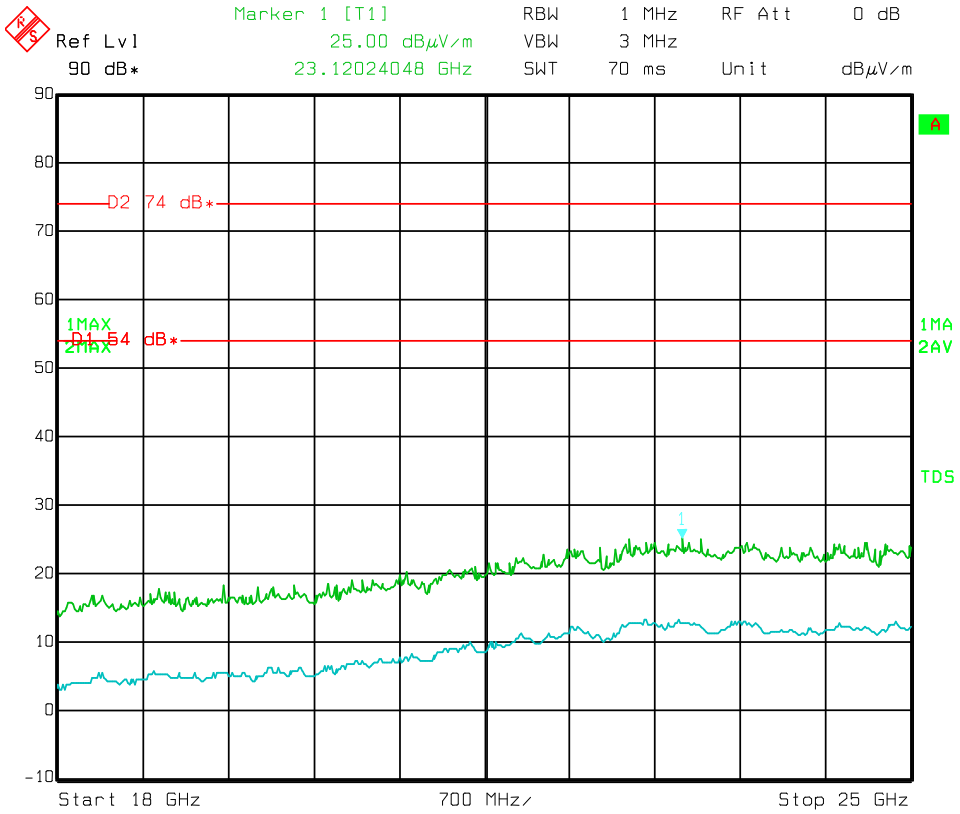


Figure 8.4-23: *Radiated spurious emissions for frequency range 18 GHz to 25 GHz with antenna in horizontal polarization, high channel*

Channel	Frequency, MHz	Peak Field strength, dBµV/m		Margin, dB	Average Field strength, dBµV/m		Margin, dB
		Measured	Limit		Measured	Limit	
High	No spurious detected						

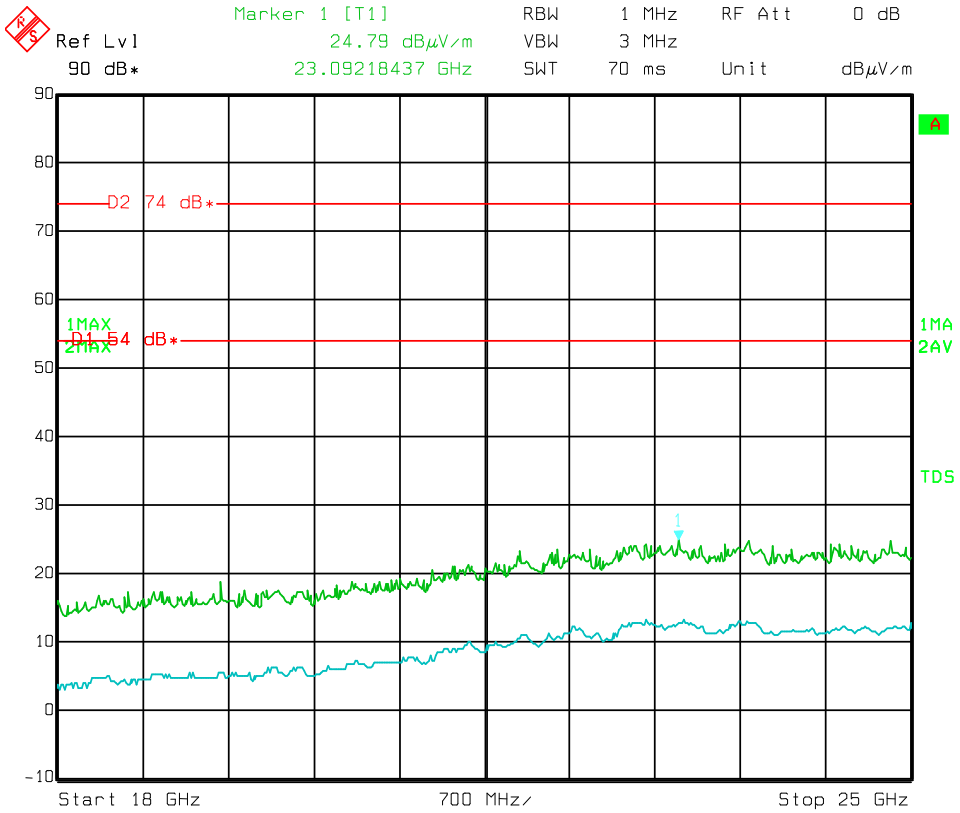


Figure 8.4-24: *Radiated spurious emissions for frequency range 18 GHz to 25 GHz with antenna in vertical polarization, high channel*

Channel	Frequency, MHz	Peak Field strength, dBµV/m		Margin, dB	Average Field strength, dBµV/m		Margin, dB
		Measured	Limit		Measured	Limit	
High	No spurious detected						

8.4.5 Band-edge evaluation

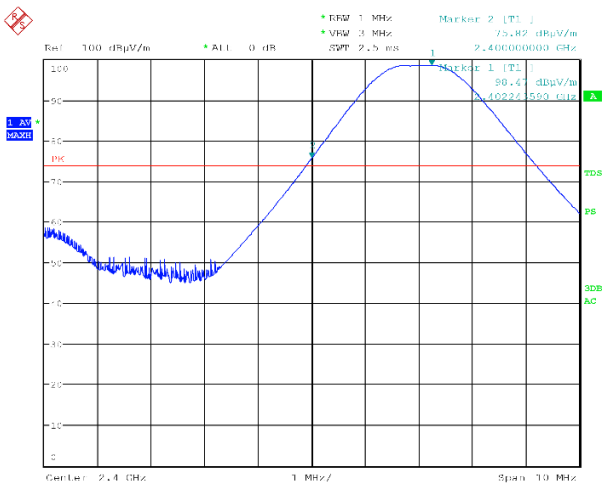


Figure 8.4-25: *Lower edge with 1 MHz RBW and Peak detector*

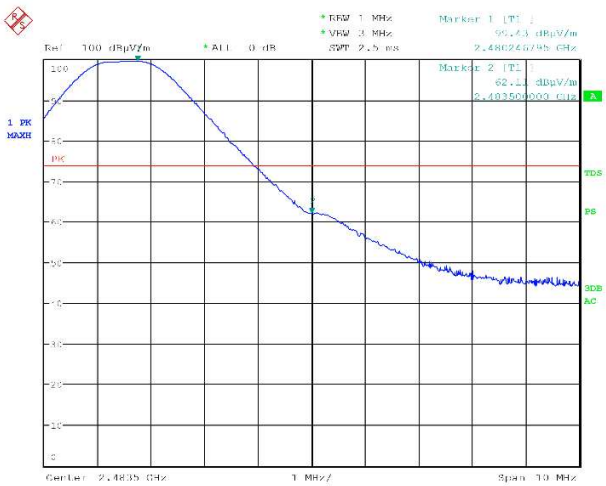


Figure 8.4-26: *Upper edge with 1 MHz RBW and Peak detector*

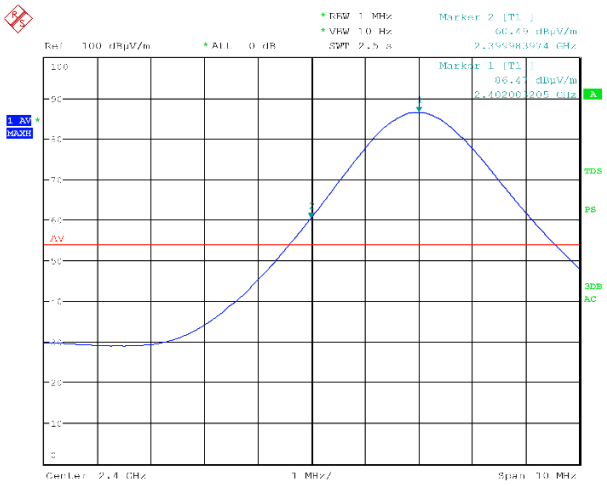


Figure 8.4-27: *Lower edge with 1 MHz RBW and Average detector*

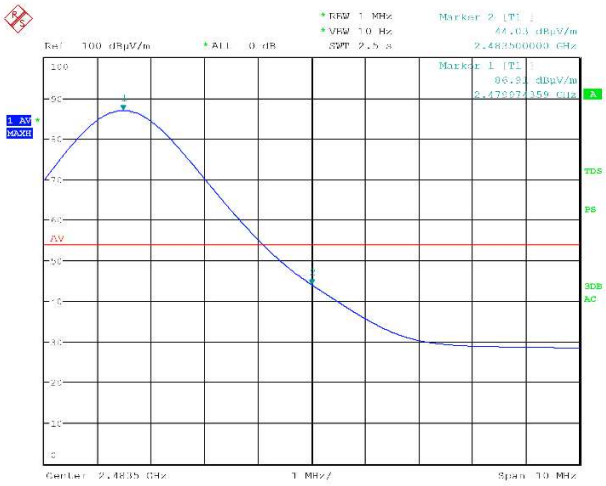


Figure 8.4-28: *Upper edge with 1 MHz RBW and Average detector*

Table 8.4-4: *Band-edge evaluation*

Band edge	Measured, dBc	Limit, dBc	Margin, dB
Lower edge (PK detector)	22.6	20.0	2.6
Lower edge (AV detector)	26.0	20.0	6.0
Upper edge (PK detector)	42.9	20.0	22.9
Upper edge (AV detector)	37.3	20.0	17.3

8.5 FCC 15.247(e) and RSS-247 5.2(b) Power spectral density for digitally modulated devices

8.5.1 Definitions and limits

FCC:
For digitally modulated systems, the power spectral density conducted from the intentional radiator to the antenna shall not be greater than 8 dBm in any 3 kHz band during any time interval of continuous transmission. This power spectral density shall be determined in accordance with the provisions of paragraph (b) of this section. The same method of determining the conducted output power shall be used to determine the power spectral density.

IC:
The transmitter power spectral density conducted from the transmitter to the antenna shall not be greater than 8 dBm in any 3 kHz band during any time interval of continuous transmission. This power spectral density shall be determined in accordance with the provisions of Section 5.4(d), (i.e. the power spectral density shall be determined using the same method as is used to determine the conducted output power).

8.5.2 Test summary

Test date	July 3, 2017	Temperature	22 °C
Test engineer	Paolo Barbieri	Air pressure	1020 mbar
Verdict	Pass	Relative humidity	31 %

8.5.3 Observations, settings and special notes

The test was performed using method PKPSD. Spectrum analyser settings:

Resolution bandwidth:	3 kHz to 100 kHz
Video bandwidth:	≥ 3 x RBW
Frequency span:	1.5 × DTS channel BW
Detector mode:	Peak
Trace mode:	Max hold
Sweep time:	Auto couple

8.5.4 Test data

Table 8.5-1: *PSD measurements results*

Modulation	Frequency, MHz	PSD, dBm/3 kHz	PSD limit, dBm/3 kHz	Margin, dB
BLE	2402	-8.3	8.00	16.3
	2440	-9.1	8.00	17.1
	2480	-9.3	8.00	17.3

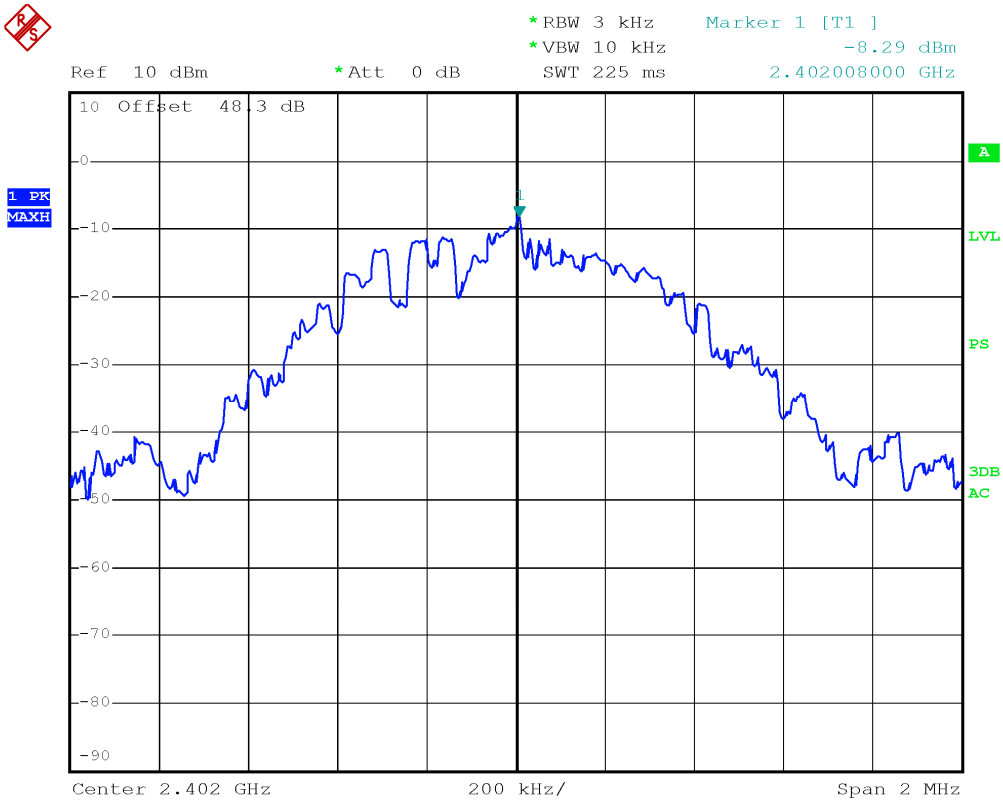


Figure 8.5-1: *PSD sample plot on channel low*

Figure 8.5-2: *PSD sample plot on channel mid*

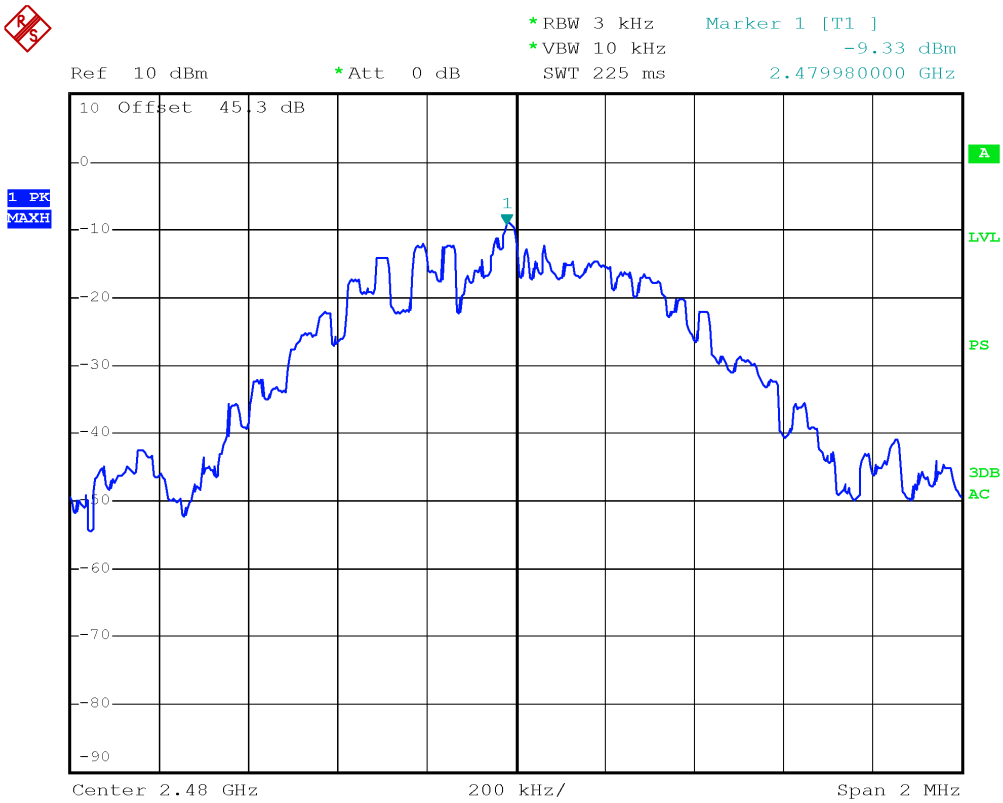
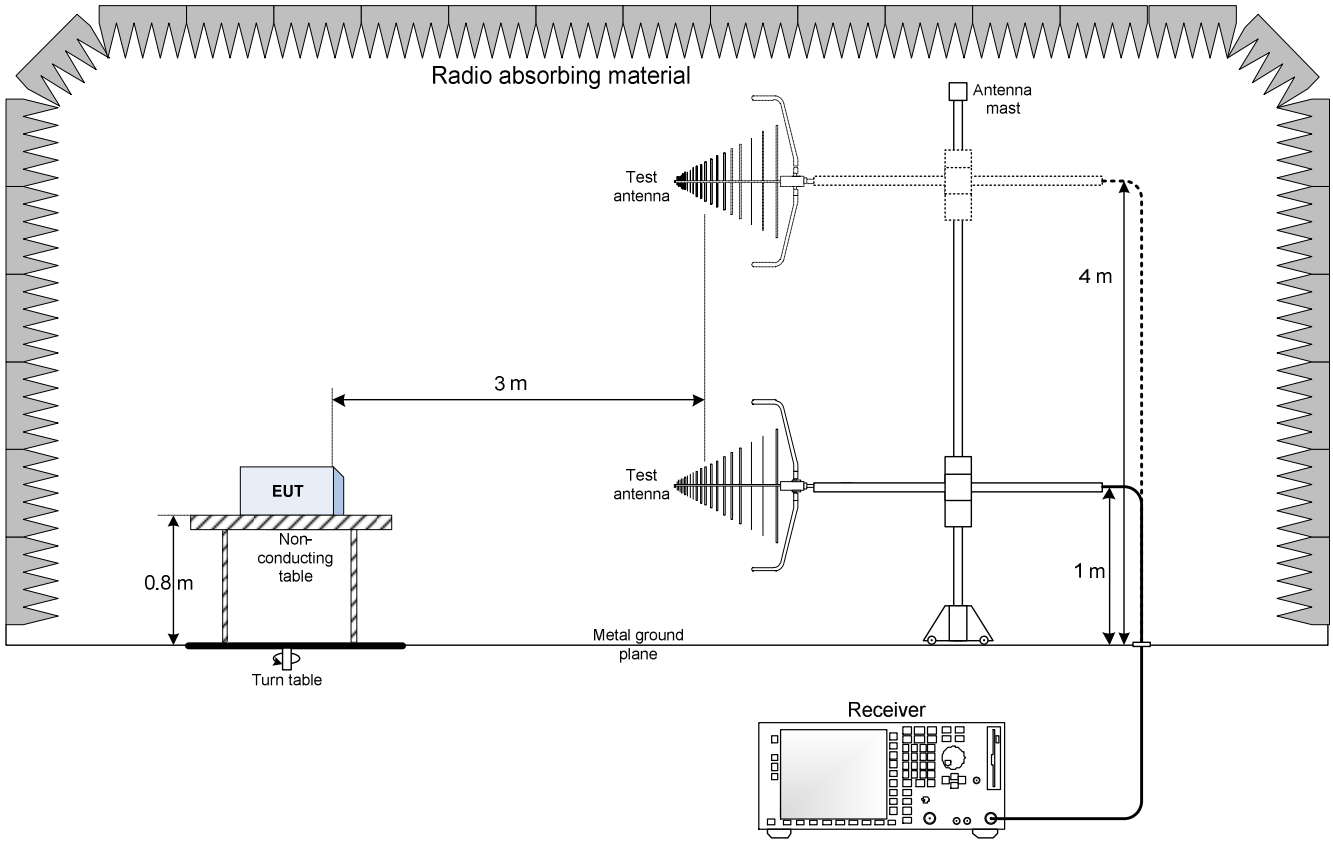


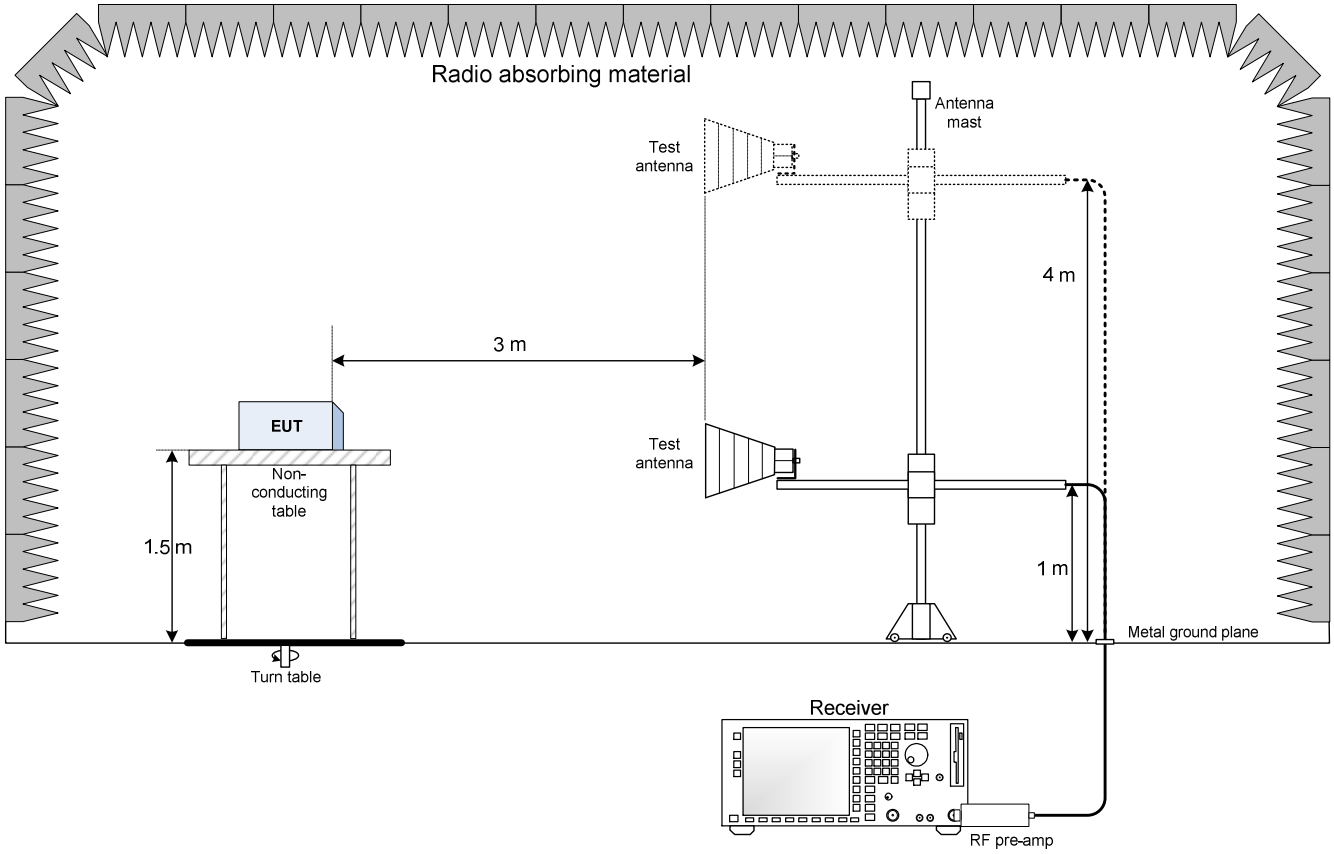
Figure 8.5-3: *PSD sample plot on channel high*

Section 9. Block diagrams of test set-ups

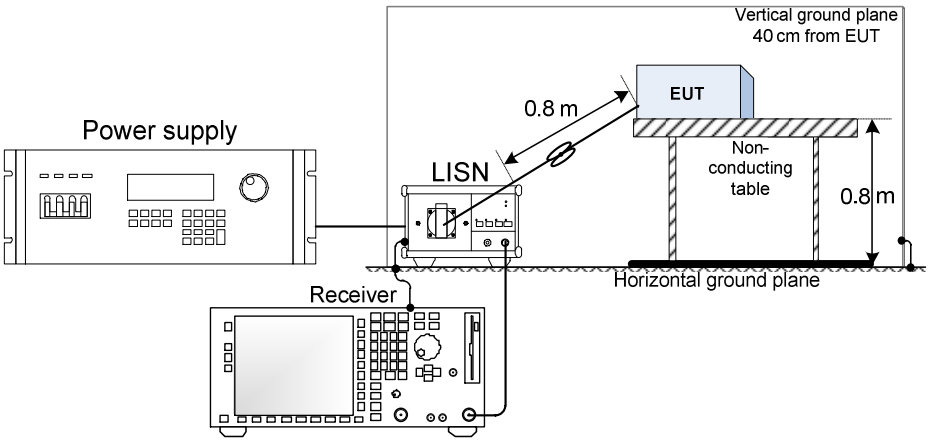
9.1 Radiated emissions set-up for frequencies below 1 GHz



9.2 Radiated emissions set-up for frequencies above 1 GHz



9.3 Conducted emissions set-up



Section 10. Set-up photos and EUT photos

10.1 Photo documentation of the test set-up

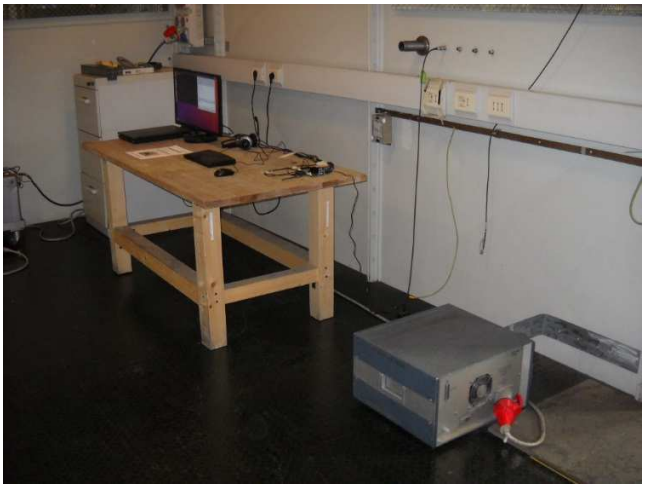


Figure 10.1-1: *Conducted emission test*

Figure 10.1-2: *Radiated emission test below 1 GHz*

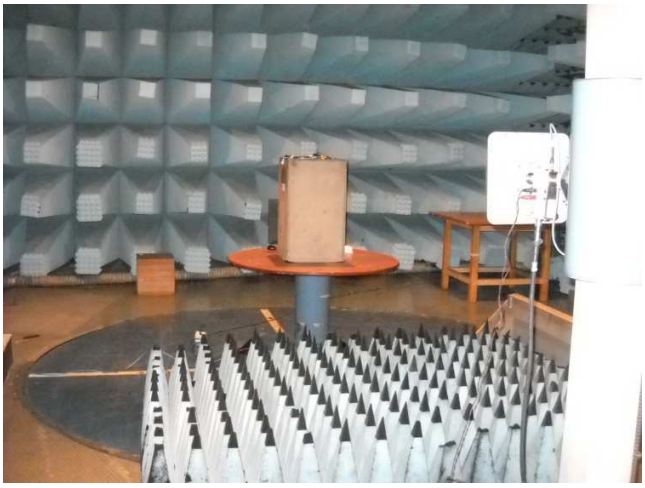


Figure 10.1-3: *Radiated emission test above 1 GHz*

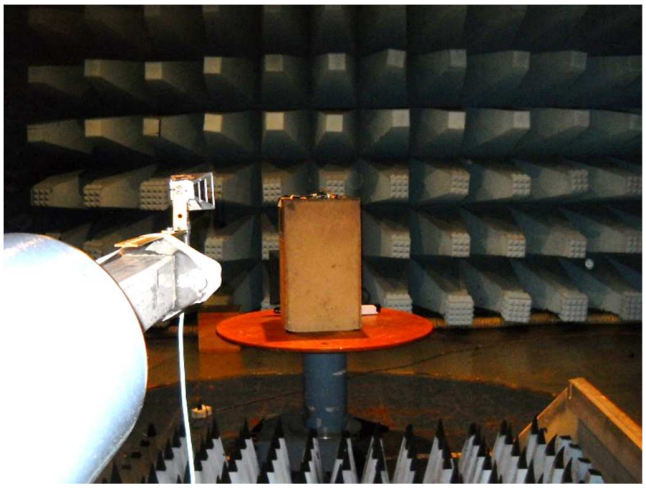


Figure 10.1-4: *Radiated emission test above 18 GHz*

10.2 EUT photos